

ENVIRONMENTAL PROTECTION
COMMISSION ON RADIATION PROTECTION

Soil Remediation Standards for Radioactive Materials

Adopted New Rules: N.J.A.C. 7:28-12

Proposed: July 6, 1999 at 31 N.J.R. 1723(a)
Adopted: June 21, 2000 by Robert C. Shinn, Jr., Commissioner, Department of Environmental Protection and the Commission on Radiation Protection, Dr. Henry Powsner, Chairman
Filed: July 6, 2000 as R.2000d.314, **with substantive and technical changes** not requiring additional public notice and comment (see N.J.A.C. 1:30-4.3).
Authority: N.J.S.A. 26:2D-1 et seq. and 58:10B-1 et seq.
DEP Docket Number: 11-99-06/697
Effective Date: August 7, 2000
Expiration Date: February 25, 2005

Summary of Public Comments and Department Responses:

The following companies, organizations, and/or agencies submitted written comments on the proposal.

1. CBS Corporation
2. US Environmental Protection Agency
3. US Nuclear Regulatory Agency
4. NL Industries
5. Shieldalloy Metallurgic Corporation
6. US Department of the Army - Corps of Engineers
7. New Jersey Environmental Federation representing 90,000 members
8. Heritage Minerals Inc.
9. Howmet Corporation
10. Zirconium Environmental Committee

11. Coalition Against Toxics
12. Public Service Electric & Gas
13. Oak Ridge Institute for Science and Education

A summary of the comments timely submitted and the Department's responses follows.

The numbers in parenthesis after each comment corresponds to the commenter(s) listed above.

General

1. COMMENT: Five commenters expressed support for the Department's efforts to develop generically applicable standards that are easy to use and flexible, to assist persons responsible for planning and conducting site remediations. (2, 1, 6, 10, 3)

RESPONSE: The Department appreciates the commenter's support.

2. COMMENT: One commenter expressed opposition to the entire proposal in that it is in conflict with federal standards, technically indefensible, and unduly burdensome with no corresponding benefit. (5) Two commenters could not support the proposal because it allows so much latitude for leaving untreated contaminants on site. (7, 11)

RESPONSE: The Department disagrees with the comments and addresses these points more specifically in the responses to comment numbers 26, 37, 68, and 70.

3. COMMENT: One commenter expressed concern that no mention is made of "grandfathering" sites that are currently in the midst of decommissioning or will begin decommissioning prior to the implementation of the rule. For active sites, the State should recognize approved existing clean-up criteria that NRC licensees are working to meet. Applying new criteria in the middle of a cleanup project could have technical and legal consequences for all parties involved. The commenter would also like to see a reasonable phase-in period of at least one year established to prevent licensees who have committed a substantial investment in this process from ceasing clean-up operations due to changing clean-up criteria or significantly altering complex budgetary plans and schedules. (1)

RESPONSE: The Brownfield and Contaminated Site Remediation Act (Brownfield Act) at N.J.S.A. 58:10B-12, specifies that the Department may not require a change to a Department-approved workplan in order to compel a different remediation standard due to the fact that the

established remediation standards have changed; however the Department may compel a different remediation standard if the difference between the new remediation standard and the remediation standard approved in the workplan or other plan differs by an order of magnitude. The Department believes that because of this provision in the Brownfield Act, and because the Department has been using the proposed remediation standards for over two years, a one year phase-in period is not necessary.

4. COMMENT: One commenter (6) claimed that the combination of not having generic guidelines for accelerator produced radionuclides, the premix levels specified only to USS less than 5, the fact that other radionuclides could be covered based on laws requiring clean up, the specifics of building construction related to radon, etc. means that the standards listed in N.J.A.C. 7:28-12.9 will have limited use. In most cases the alternative approach outlined in N.J.A.C. 7:28-12.10 will be used. This will not be much different than the current practice. The stated parameter inputs Tables 6 and 7 may be a better way to approach this problem, i.e. standardize the risk model parameters.

RESPONSE: Most of the contaminated properties in New Jersey contain only the naturally occurring radioactive materials. However, development of standards for nuclides not addressed in this proposal will not cause undue burden on the owner because, as stated in the comment, the acceptable parameters and dose criteria are established in the Technical Basis document. This was not the case in past practice. Inclusion of the alternative standard approach (N.J.A.C. 7:28-12.10) is required as per legislative directive in the Brownfield and Contaminated Site Remediation Act (BCSRA).

5. COMMENT: One commenter stated that there does not appear to be any collaborating information presented for the Department's statement that "the minimum remediation standards for soil should result in less expensive remediations by eliminating the requirement for site-specific dose assessments." It might be true for a small site with limited quantities of contamination but for a larger complex project with significant amounts of contamination it does not seem that it would be true. It would seem necessary to conduct the site-specific dose assessments to determine the potential exposures. (6)

RESPONSE: If site-specific dose assessments were necessary, the Department's spreadsheet, RaSoRS, could be used to easily develop the proper remediation standards. Parameters, such as the lot size may be changed easily. There would still be no need to perform a completely independent site-specific dose assessment.

6. COMMENT: One commenter noted that the summary, technical basis document, and the proposal differ in varying areas. (6)

RESPONSE: Through the responses to comments number 72 and 93, the Department corrected inconsistencies.

7. COMMENT: Two commenters asked what precautions will be taken to ensure the health of the workers and the residents in the area during the remediation and construction phases. (7, 11)

RESPONSE: These issues are addressed in the Site Remediation Technical Requirements N.J.A.C. 7:26E-1.9, Health and Safety Plan. Radioactively contaminated sites that are being remediated employ air sampling and dust and erosion control to prevent off-site migration of contaminants.

8. COMMENT: Two commenters (7, 11) expressed concern about the seepage of radioactive material into basements.

RESPONSE: The generic standards were developed taking into account the seepage of radon gas into a basement. Because of this potential for radon entry, this was the limiting pathway that determined the radium-226 (the parent of radon) remediation standards.

9. COMMENT: Two commenters wondered if bioremediation or phytoremediation could be utilized to clean up some of these radioactive sites. (7, 11)

RESPONSE: These techniques could be employed. The adopted rule does not prohibit their use.

10. COMMENT: Two commenters expressed concern that since some naturally occurring radioactive material may take thousands of years to dissipate, what safeguards would be in place to monitor and maintain these sites? Also, what health

monitoring would be afforded to those workers and people who will be living and working at these "cleaned up" sites? (7, 11)

RESPONSE: A remedial action for a site that was contaminated with radionuclides for which this rule includes applicable cleanup standards, must (i) allow for the unrestricted use as a result of the remedial action remediating all exposure to the radionuclides above the unrestricted use standard; (ii) allow for limited restricted use via the use of institutional controls, such as a deed notice; or (iii) allow for restricted use via both institutional and engineering controls, such as a cap or barrier. When an unrestricted use remedial action is performed, there is no residual contamination that would support any health monitoring because the annual dose is within the normal background range that one would receive from traveling to different places within the New Jersey. For limited restricted use and restricted use remedial actions, some residual contamination remains at the site after the remedial action is performed. While these regulations do not automatically require health monitoring of workers at a remediated site, there are several mechanisms in place that require the continual review of these last two remedial actions to ensure that they remain protective of the public health and safety and of the environment over time. First, the Technical Requirements for Site Remediation require the person that is responsible for conducting the remediation to include in the remedial action workplan a "description and schedule for the maintenance and evaluation . . . of all engineering and institutional controls." N.J.A.C. 7:26E-6.2(a)18. Second, the Technical Requirements for Site Remediation also require the person responsible for conducting the remediation to maintain all engineering and institutional controls, to conduct periodic inspections of the controls, and to submit monitoring reports to the Department. See, N.J.A.C. 7:26E-6.4(g). Third, at the completion of the remedial action, the Department will issue a no further action letter that includes a covenant not to sue pursuant to N.J.A.C. 7:26C-2.6. All covenants not to sue contain "a provision requiring the person [responsible for conducting the remediation], or any subsequent owner, lessee, or operator during that person's period of ownership, tenancy, or operation, to maintain those [engineering and

institutional] controls, conduct periodic monitoring for compliance, and submit to the department, on a biennial basis, a certification that the engineering and institutional controls are being properly maintained and continue to be protective of public health and safety and of the environment." N.J.S.A. 58:10B-13a.(2)(a). Finally, each deed notice details the maintenance and monitoring requirements necessary to ensure that the remedial actions which included engineering and/or institutional controls remain protective and provide notice that the owner and any subsequent owner, lessee, or operator have the obligation to perform that maintenance and monitoring of the remedial action.

11. COMMENT: One commenter supported the Department's allowance of *in situ* remedies and presented evidence that these techniques are consistent with CERCLA in that they are designed to reduce toxicity and mobility of the hazardous substance. The commenter quotes Section 121(b) of CERCLA which states:

Remedial actions in which treatment which permanently and significantly reduces the volume, toxicity or mobility of the hazardous substances, pollutants, and contaminants as a principal element, are to be preferred over remedial actions not involving such treatment. The offsite transport and disposal of hazardous substances or contaminated materials without such treatment should be the least favored alternative remedial action where practicable treatment technologies are available. The President shall conduct an assessment of permanent solutions and alternative treatment technologies or resource recovery technologies that, in whole or in part, will result in a permanent and significant decrease in the toxicity, mobility, or volume of the hazardous substance, pollutant, or contaminant....

The examples of remedies in the proposal that were supported by the commenter include: removing part of the contamination and placing uncontaminated surface soil over the residual contamination; mixing contaminated soil with uncontaminated portions of the site; removing the most contaminated soil and mixing with uncontaminated soil on the surface; or treating the contaminated soil to reduce the volume destined for disposal followed by dispersal of treated soil. None of the suggested remedies are in conflict with

CERCLA Section 121(b). The commenter felt that the proposed soil remedies are consistent with CERCLA and cited a court decision (*United States v. City and County of Denver*, 100F.3d 1509,1512) to illustrate. In that case, involving a site contaminated by radium tailings, Denver had a local zoning ordinance that prohibited a property owner from maintaining hazardous wastes on-site in an area zoned for industrial use. A remedial order issued by the Environmental Protection Agency required on-site stabilization of the contaminated soils. The court determined that a zoning requirement which unduly restricted remedy selection frustrated the remedial purposes of CERCLA.

This [Denver] zoning ordinance also stands as an obstacle to the objectives of CERCLA, whose purpose is to effect the expeditious and permanent cleanup of hazardous waste sites, and to allow the EPA the flexibility needed to address site-specific problems. CERCLA § 9621(b)(1)(expressing preference for on-site, permanent remedies); H.R. Rep. No. 99-253(I), 99th Cong., 2d Sess., at 58, reprinted in 1986 U.S.C.C.A.N. 2835, 2840 (stating that EPA should select efficient and permanent cleanups when possible); *id.* at 2839 (stating that the 1986 amendments to CERCLA were designated in part to leave the EPA sufficient flexibility to address site-specific problems). *A zoning ordinance which bars the maintenance of hazardous waste dramatically restricts the range of options available to the EPA, and in this case the ordinance would prevent a permanent on-site remedy.* 100 F. 3d 1509 at 1512 (emphasis supplied).

The commenter states that it would appear that a reviewing court would conclude that the in-situ remedial options proposed by the Department are consistent with CERCLA §121(b). Moreover, a soil-blending/mixing remedy would be particularly appropriate for sites contaminated with “technologically enhanced NORM,” in which anthropogenic influences have led to NORM concentrations above natural levels. Put another way, “technological un-enhancement” offers a logical and economically efficient solution to site remediation, consistent with the State’s authority to implement flexible on-site remedies under CERCLA. (10)

RESPONSE: The Department agrees that in certain unique situations, where native materials were mined and in the process the naturally occurring nuclides were concentrated, returning this material to its natural state, or "technologically un-enhancing" by blending with the depleted portion, is appropriate. This would not be appropriate at sites which imported non-native materials.

12. COMMENT: One commenter was concerned that the proposed regulation does not meet the standard required for validity of an administrative regulation of this type, as specified by *Campbell Foundry Co. v. Sullivan*, 119N.J. Super. 51 (App. Div. 1972), i.e., that the measures be "not unreasonably costly in the light of the nature and utility of the industrial operation affected as well as the harm which failure to use them would visit upon the environment." Nor does the rule meet the "arbitrary, capricious, unreasonable or otherwise unlawful" standard, or principle of administrative rule-making set forth in *Matter of Rulemaking*, N.J.A.C. 10:82-1.2 & 10.85-4.1, 117 N.J. Super 311 (1989), that is, the Department, in applying legislative policies to facts, clearly erred by reaching conclusions that could not reasonable have been made upon a proper consideration of the underlying factors. (5)

RESPONSE: The Department believes that its implementation of the legislative mandate, discussed in the proposal, is neither arbitrary, capricious or unreasonable. The rule provides the regulated community with a flexible means of remediation existing environmental harm and danger to human health, and facilitates the return of valuable property to productive use.

The Use of 15 mrem/yr as a Dose Criterion

13. COMMENT: One commenter stated that the Department adopted a 15 mrem/yr limit assuming more than one source of exposure may exist producing a total dose of 100 mrem/yr. The same commenter states that the there is no technical basis for selecting 15 mrem/yr, yet it appears that the Department is following the USEPA lead in adopting this standard. Another commenter stated that with respect to USNRC's (and USEPA's similar) 15 mrem/y proposed limit, NRC's Advisory Committee on Nuclear Waste (ACNW) has stated that while the need to

partition the *annual* dose limitation to the public (100 mrem/y) among several sources appears justifiable, the proposed one-seventh limit is “an unnecessarily conservative fraction” of the annual limit. The assumption, and indeed an unsupported one, [NRC made no attempt to show that any members of the public are likely to be exposed to multiple licensed source, including decommissioned sites, that would suggest that the 100 mrem/y limit for members of the public would be exceeded. The National Council on Radiation Protection and Measurements suggests that non-medical, man-made sources of radiation doses to the public are well below 15 mrem/y. (NCRP Report No. 93 (1987), p. 53, Table 8-1)], that a person will encounter “a simultaneous dose from seven different, regulated sources appears to be unjustified.” ACNW suggests that one-third or one-fourth of the 100 mrem/y limitation is more easily justified based on the likelihood that no more than three or four regulated sources will affect any exposed person. (6)

RESPONSE: The Department did not determine the 15 mrem/yr based on the criteria suggested by the commenter. The Department was required by the Brownfield Act to develop generic remediation standards based on either a one in one million risk or regional natural background levels. The Department did not follow the USEPA's lead in proposing this standard. It is coincidental that the Department's standard is equivalent to the USEPA's acceptable dose limit. The Department does not believe that 15 mrem/y is an unnecessarily conservative dose criterion since it is in the upper range of the USEPA's acceptable risk range of 10^{-4} to 10^{-6} .

14. COMMENT: Five commenters expressed concern about the Department's determination of regional background. Concerns were:

- "Background" values used by the Department are not state- or area-specific. Instead, national-averages, as reported by the National Council on Radiation Protection and Measurements (NCRP) are taken to be representative of conditions in New Jersey.
- In some areas there will be more variation within the 'local' area than is present across the 'regional' area.
- The derived background using national data is not consistent with the requirement to use regional natural background in the Brownfield Act.

- Using the Department's definition of regional background (the mean plus one standard deviation), the concentration of naturally-occurring radioactivity at 16 percent of the United States land area where there has been no form of technological enhancement or man-made intervention would exceed the Department 's release criteria. Statistical variations alone will drive the unnecessary clean-up of sites with radiological constituents that are well within the range of natural background concentrations.
- The contribution to regional background exposure from radionuclides in drinking water is not considered. (5, 10, 6, 11, 7)

RESPONSE: The Department's dose criterion is an allowed increment **above background**. Therefore, the comments regarding cleanup of unaffected areas or uncontaminated soil are not germane. The person responsible for conducting the remediation is required to first establish background in the vicinity of the site. The remediation standard is then added to the background concentration. The reason that the Department used national data to determine a reasonable approximation of background is because there was insufficient New Jersey specific data. The data that the Department has is biased toward areas of elevated radium soil concentrations (because of the naturally occurring radon problem in New Jersey). Therefore, the Department took a reasonable approach by using the national data presented in NCRP 94. However, only the geologic areas that occur in New Jersey were used in developing the dose criterion. The Department did not consider naturally occurring radium in drinking water in determining background because this is a contaminant that is regulated by the State. If levels of radium are high, the water is treated, thereby eliminating that dose. Alternately, naturally occurring radionuclides in rocks and soils are not regulated as a contaminant and were considered in determining background.

15. COMMENT: One commenter was concerned that the use of the limit of one standard deviation is not consistent to other industry standards, i.e. most environmental regulations are based upon a 90-95 percent confidence limit which is two standard deviations. Such a low confidence limit (68 percent using one standard

deviation) will result in a false positive rate of 32 percent, which means that 32 percent of the time sites will be cleaned up that are not exceeding background concentrations. (6)

RESPONSE: The commenter has assumed that the Department's use of one standard deviation to determine an acceptable State background is identical with using standard deviation in the analysis of data sets. This is not the case, and false positives (Type I errors) are addressed in the NJDEP's Field Sampling Procedures Manual, incorporated by reference at N.J.A.C. 7:28-12.5(e), which follows the guidance in the Multi-Agency Radiation Site Survey Investigation Manual (MARSSIM) closely.

16. COMMENT: One commenter was concerned about the derivation of the one standard deviation because environmental data are considered to have lognormal rather than normal distributions which can affect the interpretation. (8)

RESPONSE: If the data are expressed as a graph of percentage of the population exposed vs. dose, it is a normal distribution.

17. COMMENT: One commenter was concerned that the allowed increments from the internal and external pathways were statistically summed with the assumption that the values were statistically independent. This would be incorrect since not only are doses from the external and internal pathways for the same radionuclide highly correlated under natural conditions, the concentrations of natural radionuclides are also highly correlated. The assumption of independence will underestimate the standard deviation in dose. (8)

RESPONSE: The Department's research suggests that the doses from the external and internal pathways for the same nuclides are not highly correlated with the exception of potassium-40. Potassium-40 was not included in the determination of the internal dose increment because the variation is small and mostly unrelated to intake. The following table illustrates the independence of the external and internal doses

Percentage of Dose Contribution		
Radionuclide	Terrestrial Gamma Radiation*	Intake**

K-40	36%	30%
Th series	47%	
Uranium Series		
Radium-226-Po214	17%	6%
Pb210-Po-210	0%	50%

* National Council on Radiation Protection and Measurements. 1987. *Exposure of the Population in the United States and Canada from Natural Background Radiation*. NCRP Report No. 94.

** Fisenne, I.M.. 1993. *Long-Lived Radionuclides in the Environment, in Food and in Human Beings*. in Fifth International Symposium on the Natural Environment- Tutorial Session. Commission of European Communities. Report EUR 14411 EN. pp. 187-255. Table 9, p. 241.

18. COMMENT: Two commenters asked what happened to the Department's directive to protect the health and welfare of the general population? What criteria is the Department using when determining the safe allowable annual dose of radiation? What is the approximate number of additional cancer cases that will result from the application of this standard? What is the additional cancer risk associated with "naturally occurring" background levels? If the property is allowed to be developed into a residential housing, has consideration been given to the fact that some of the residents may have compromised immune systems, or may be infants, children, or women of child bearing age? (11, 7)

RESPONSE: The Department considers the derived dose criterion, 15 mrem/yr, to be protective of the health and welfare of the general population. The criteria used to determine this dose was obtained from the legislative directive in the Brownfield Act, which states that remediations shall not be required beyond the regional natural background levels for any particular contaminant. This dose results in three additional cancer cases out of 10,000 people exposed over a lifetime (70 yrs). This means that if 10,000 people were to live on a site remediated to 15 mrem/yr, drink water from a well on the site, eat fruits and vegetables grown on the site, and spend time outside everyday on the site for 70 years, we would expect to see three additional cancer cases in the 10,000 people exposed. The USEPA considers this as being within

the CERCLA risk range (10^{-4} to 10^{-6}). As a comparison, all sources of naturally occurring background radiation (cosmic, terrestrial, internally deposited, excluding naturally occurring radon) result in a dose of approximately 100 mrem/yr. This translates into a lifetime risk of 20 additional cancer cases out of 10,000 people exposed. If naturally occurring radon is included, the risk is much higher, as much as 600 additional cancer cases out of 10,000 people exposed. This is typical of background for New Jersey. The population in Colorado is exposed to an additional dose of 100 to 200 mrem/yr from an increased terrestrial (greater concentration of naturally occurring radionuclides present in soil and rocks) and cosmic (greater elevation) radiation.

The risk can be calculated for an annual dose of 15 mrem. Using the latest USEPA risk coefficients in Federal Guidance No. 13, the risks are on the order of one in ten thousand for each soil remediation standard. Risk coefficients used by the USEPA for radiation risk assessment explicitly account for the fact that children are more sensitive to radiation than adults. The age-specific, organ-specific risk per unit dose coefficients used in the lifetime risk model apply the appropriate age-specific sensitivities throughout the model. In developing lifetime risks, the model uses the life table for a stationary population. Use of the life table allows the model to account for competing causes of death and age-specific survival.

Considering that the allowable dose for pregnant radiation workers is 500 mrem for the duration of the pregnancy, the Department believes that the 15 mrem/y dose criterion is sufficiently conservative.

The increased risk from 15 mrem/yr (3 out of 10,000) should also be viewed in the context of current cancer statistics. According to the American Cancer Society, approximately 4,300 people in 10,000 will develop cancer at some point in their lifetimes. Considering the National Council on Radiation Protection and Measurements regards 100 mrem/yr to be protective of public health, the Department believes that the selected dose criterion is protective.

The standard was based on modeling of the **average member of the critical group** which includes the most highly exposed individuals. It did not consider individuals with depressed immune systems. Since these individuals are exposed to 6-20 times the dose criterion from

normal background radiation, it is the Department's position that this approach is justified.

19. COMMENT: One commenter was concerned about the ability to establish background levels in an area that was mined for its heavy mineral content. The highest naturally occurring areas would be the first to be mined, therefore they are not present to contribute to the background. (8)

RESPONSE: The Department agrees that it may be difficult to establish background in a disturbed area. However, this situation can be addressed on a site-specific basis and need not be addressed in the rule. Establishing background is outlined in the Department's Field Sampling Procedure's Manual.

20. COMMENT: One commenter stated that even though the proposed rules expand allowable remedial options (e.g. removing, mixing, covering, land use restrictions and combinations thereof) the proposed 15 millirem per year (mrem/y) TEDE limit is so restrictive, in and of itself, that when combined with restrictive requirements for demonstrating compliance, the limit becomes unworkable at any site, such as the commenter's site, where heavy minerals exist that contain wide variations in naturally occurring radioactivity levels. As a result, the commenter is compelled to restate some of its comments made in response to the State's pre-proposal draft in 1996 that were not addressed in the current proposal and its support package. It is the commenter's opinion that a 15 mrem/y limit is inappropriate for non-Atomic Energy Act (AEA) licensed facilities that produce some naturally occurring radionuclide soil contamination as a result of their non-AEA licensed processes. The Nuclear Regulatory Commission (NRC), which originally proposed a similar 15 mrem/y limit has acknowledged significant problems with identifying contamination versus natural background radionuclides where diffuse Naturally Occurring Radioactive Materials (NORM) is involved because of the low level of radionuclides in soil that implicate a 15 mrem/y exposure. A tabletop exercise involving NRC staff and representatives of the Fuel Cycle Facilities Forum (FCFF) tested NRC staff's proposed guidance for implementing its proposed 15 mrem/y limit. The exercise used real data from an existing site and found that the minimum detectable concentration (MDC) (derived from NRC's formula which uses variability in background concentrations at the reference site) exceeded the guideline

concentrations of uranium and thorium that generate exposures at the 15 mrem/y limit. Given instrument and laboratory variability it appears that even abandoning NRC's codes and guidance and creating new approaches may not provide sufficient assurance that the license is addressing contamination and not natural background concentrations. (8)

RESPONSE: The Department's incremental 15 mrem/yr criterion translates to an allowable soil concentration of from 10 to 59 picoCuries per gram (pCi/g) of U-238 depending on the thickness of the contaminated zone. Considering background is typically 1 pCi/g, the problem regarding the MDC is moot. The Department recognizes that because of the sum of the fractions requirement (that the 15 mrem/yr is the total dose received from all nuclides at the site) the allowable soil concentration could be close to background when uranium is in equilibrium with radium, and thorium is present as well. In order to address this issue the Department has modified Chapter 12 of the Department's Field Sampling Procedures Manual to include reference to Scenario B of NUREG 1505, A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys, to address areas where the contaminant is indistinguishable from background.

21. COMMENT: One commenter stated that given the State's need to tie its cleanup standard to natural background the Health Physics Society's (HPS) suggestion to use natural background as a cleanup or remediation goal, "depending on the interpretation placed on that description" and assuming that site cleanup standards should be based on "achieving the greatest overall good for the public" in combination with the NRC's Advisory Committee on Nuclear Waste recommendation makes good sense. (HPS Position Statement, "Return to Background", February 1994, p. 10-12.). According to the HPS, the average dose rate for the U.S. population from terrestrial gamma radiation is 28 mrem/y and the average dose rate from internal radiation exposure is 40 mrem/y. Although there are significant variations in dose rates depending on location, the average dose rates from cosmic and terrestrial gamma in the coastal plain are about 50 mrem/y while the dose rate from internal radiation varies little regardless of location, HPS further reasons that:

For purposes of limiting lifetime risk, a site-specific dose rate of 10-30 mrem/y greater

than the regional average is well within the natural variations of background and should be considered equivalent to background and without demonstrable increased risk. (HPS Position Statement, "Return to Background", February 1994, p. 12.)

Thus, if coastal plain averages for direct gamma exposure would be approximately 25 mrem/y (one-half of combined gamma and cosmic exposure) and average internal exposure is 40 mrem/y, then 10-30 mrem/y in excess of the regional average of 60-65 mrem/y (i.e., 70 to 100 mrem/y) should be the *range* of natural background *variation* for DEP's consideration. As the HPS notes, "[c]onditions that produce a distribution of radiation doses and risks to people within the normal range of background should be regarded as natural." (HPS, "Radiation Cleanup Standards," p. 10 (emphasis added)). Even assuming NRC's approach to building in a safety factor (i.e., by partitioning the dose attributable to background *variation*) were to be utilized, an annual limit on the order of 35-40 mrem would seem reasonable to satisfy the State's statutory directive that the incremental contamination/exposure allowable be within the range of natural background "consistently" *present* the environment of the region of the site. The NRC finally settled on 25 mrem/y. (8)

RESPONSE: The Department thanks the commenter for providing further justification that 15 mrem/y is an appropriate dose criterion since it is within the dose range specified by the Health Physics Society (10-30 mrem/y) for limiting lifetime risk. The 35-40 mrem/y suggested by the commenter is not within this range, nor would it fall within the USEPA's acceptable risk range of 10^{-4} to 10^{-6} .

22. COMMENT: One commenter stated that in establishing the 15 mrem/year dose limit based on the total dose increment, the State took credit for the shielding that the building provides from external exposure originating outside the building while people are indoors (see Section 2.1.1 of the Technical Basis Document). The State did not account for the indoor exposure from building materials. The National Council on Radiation Protection and Measurements Report 94, the document used for external gamma rate data, discusses indoor gamma exposure and concludes that indoor exposure rates on average are approximately the same as outdoor rates because the exposure from building materials tends to cancel out the dose reduction due to the

shielding effect. Thus, one could assume that the variability in indoor exposure rates is approximately the same as the variability in outdoor exposure rates. When this is accounted for, the allowable total dose increment would be increased to 18 mrem.

Additionally, the dose increment calculation takes no account of the variation of cosmic radiation across the State caused by variations in altitude. If variability in exposure rates from cosmic radiation were also accounted for, the allowable total dose increment would increase even more. (3)

RESPONSE: The Department acknowledges that the NCRP Report assumes that the average indoor exposure equals the average outdoor exposure. However, the same report also states that attempting to correct for type of dwelling would not make a significant change in the population exposure.

The variability in exposure rates from cosmic radiation from changes in altitude is negligible for New Jersey since the highest point in the State is only 1800 feet at High Point. The average elevation in New Jersey is about 150 feet.

Site Use Scenarios

23. COMMENT: One commenter stated that the proposed soil limits were derived assuming areas of 500 m² (0.12 acres) and 1000 m² (0.25 acres) for the land-use scenario for the unrestricted and restricted use cases respectively (see the "Site Use Scenarios" section of the Summary). No justification is provided for why these are considered to be appropriate land-use areas for the analysis. In addition, the proposed rule is not clear on how facilities are expected to address contaminated areas larger than these. For example, would these facilities be expected to perform their own dose analyses, and if so, would they be expected to add exposure pathways not considered because of the small land areas. Also, these assumed land-use areas are within, but less than, the upper limit recommended in the Multi-Agency Survey and Site Investigation Manual (MARSSIM) for Class 1 survey units (i.e., 2000 m²). It is unclear whether the land-use areas assumed for the dose modeling are consistent with the actual site areas and with the survey methods that will be used. (3)

RESPONSE: The Department agrees and has revised the residential and commercial lot sizes in the Technical Basis Document based on information obtained from the New Jersey State Office of Planning and confirmed by the American Housing Survey for the United States. The average lot size for a residential setting is one quarter acre and the average lot size for a commercial property is two acres. The Department believes, based on Figure 6.2 of the NRC's NUREG-5512, Vol. 1, *Residual Radioactive Contamination From Decommissioning*, that the analysis of residual risk is very insensitive to further increases in the areal extent beyond 1000 m².

It is unclear from the comment what other pathways would be added for land areas larger than these. The Department has been involved with remediations where the final land use will be a warehouse operation. These sites proposed alternative remediation standards using the land area sizes appropriate for the future use. The Department believes that, for generic standards, these lot sizes are reasonable.

Social Impact

24. COMMENT: One commenter suggested that the statement in the Social Impact statement that allows more latitude in site cleanups by allowing for dispersal, treatment, mixing and onsite disposal should be considered in the context of the regulations pertaining to other CERCLA hazardous substances and potential RCRA regulations if the radioactive material is commingled with other contaminants or pollutants. (6)

RESPONSE: The Department does not mean to imply that mixing, blending, and dispersing of other CERCLA hazardous materials is allowed. If hazardous materials other than native naturally occurring radioactive materials are commingled, then blending would not be permitted.

Economic Impact

25. COMMENT: Two commenters stated that it appears that cost of disposal is driving the policy on the issue of remediation options. Are cost and profit the main objectives of this proposal? Lessening the cost of disposal will benefit the polluters and those interested in developing these contaminated sites. The municipalities where these sites are located will also have the benefit of placing these parcels back on the tax rolls, at a much higher level of taxation.

(7, 11)

RESPONSE: The Department does not consider cost as driving the policy, as can be seen from the comments from the industry affected by the rule. The objective of this rule is to establish protective remedies.

26. COMMENT: One commenter stated that the Economic Impact Statement and the Summary state that cost reductions are likely as a result of the rule. However, the Department fails to provide a sufficient, applicable or defensible technical basis to show what the costs shown in the Economic Impact Statement are being compared to. It defies logic to think that it will cost less to comply with state regulations that are more stringent than existing federal regulations (dose basis and associated release criteria in the proposed rule are 1.7 times more stringent than those in the federal regulations). It is equally illogical to assume any savings when the proposed rule would require the costly disposal of much greater volumes of soil than would be required if clean-ups were performed under the auspices of federal regulations. (The USEPA, in 40 CFR 192, permits release of sites for unrestricted use if the radium concentrations in soil do not exceed five (5) pCi/g within the first six (6) inch layer, and 15 pCi/g in each subsequent six (6) inch layer. Thus additional and significant soil volumes beyond that required to demonstrate compliance with federal regulations would require removal and disposition in order to demonstrate compliance with the NJDEP Proposed Rule.) (5)

RESPONSE: As stated in the Federal Standards Analysis, it is difficult to compare the Department's generic soil remediation standards with the federal standards (USNRC) because the USNRC did not include soil concentration values in its decommissioning rule. However, using the USNRC's dose model, D&D, the screening soil concentration values are more stringent than the Department's proposal, even though the USNRC's dose criterion is higher than the Department's. This illustrates how the modeling assumptions used dramatically affect the resultant remediation standard and as stated in the proposal, makes it difficult to compare the USNRC soil remediation standards with the Department's. The commenter should also consider that the Department allows for limited restricted and restricted use standards which would result in less disposal costs.

To compare the Department's remediation standards to the USEPA 40 CFR 192 is not

valid since even the USEPA does not consider these standards as health-based. They should not be used at sites where the radioactive contamination is not similar to uranium mill tailings sites. In these situations, the USEPA recommends 5 pCi/g throughout the soil column, if a site-specific risk assessment demonstrates that 5 pCi/g is protective. (USEPA Directive No. 9200.4-25). Again, the USEPA does not address limited restricted and restricted use standards. Using these standards would result in lower disposal costs, as indicated in the Economic Impact section of the summary.

27. COMMENT: One commenter stated that the Department relies upon a report prepared by Computer Technology Services, Inc. (CTS) entitled, "A Review of Processes for the Removal of Selected Radionuclides from Soils" in order to arrive at implementation cost assumptions and conclusions regarding the treatment option. The CTS document, published in October of 1996, was nothing more than a literature search of available ore processing techniques and a few remedial technologies and their potential applicability to clean-up efforts attempting to achieve the NJDEP proposed criteria. (In fact the authors of the CTS report admit that the lack of availability of viable and applicable remedial technologies is a weakness in their report and its findings.) The results of the search indicated that there were **no available technologies** for separating radioactive materials in a fashion that would result in a waste stream equivalent to the release criteria established by the Department in the proposed rule. Nonetheless, the authors of the CTS report concluded that modifications to existing technologies **might** produce the desired results. Because the cost estimates used in the Department's rule are based on the findings of a literature search only, rather than on standard cost-estimating tables and industry experience in remedial actions of the types expected, and because they also assume the existence of viable and applicable remedial technologies that, in reality, do not exist, the Department's position is technically unsound. (5)

RESPONSE: The Department acknowledges, as stated in the rule proposal, that there were no available technologies that would result in a waste stream equivalent to the remediation standards presented in the proposal. That is why the Department did not assume the treatment option alone in its evaluation of cost, but in treatment and blending or dispersal. As stated in the

Economic Impact statement, the Department based cost assumptions on industry experience contained in the Department's contaminated site files, a review of an NRC document entitled *Generic Environmental Impact Statement in Support of Rulemaking on Radiological Criteria for Decommissioning of NRC Licensed Nuclear Facilities*, and industry estimates for excavation and disposal at a licensed disposal facility.

Environmental Impact

28. COMMENT: One commenter states that the Environmental Impact Statement reaches its conclusion without following even the most cursory NEPA-like evaluation (National Environmental Policy Act, 42 U.S.C. 4321, *et seq.*). While the Department concludes that the proposed rule will have a positive effect on the plants and animals in New Jersey, it does not provide a comparison of alternatives in light of public health, environmental and cost factors, including an evaluation of comparative effectiveness, reliability, implementability, useful life, and safety. (5)

RESPONSE: There are no State statutory or regulatory requirements for such an evaluation. The Environmental Impact Statement proposed is a comprehensive assessment of the impact the Department believes the rule will have on the environment.

Federal Standards Statement

29. COMMENT: Two commenters disagree with the Department's statement that it is reasonable to assume that application of As Low As Reasonably Achievable (ALARA) to the USNRC standard of 25 mrem/y would result in doses close to 15 mrem/y. Experience gained by a licensee working with the USNRC guidance document DG-4006, "Demonstrating Compliance with the Radiological Criteria for License Termination", repeatedly demonstrates that remediation below the established remediation standard is not cost effective and would not be required under the ALARA principal. (3, 1)

RESPONSE: The Department agrees with the commenters. However, the Department viewed the ALARA principle under the context of the remediation support survey. When remediations (soil removal) are performed, the instrumentation used to determine if all of the contaminated material was removed is not as accurate as laboratory sample results for

determining concentrations of radionuclides. For this reason the ALARA principle is employed and the resultant residual concentrations are often lower than the remediation standard. This is done to expedite the project so that remediated portions of the site can be backfilled before the laboratory results are received. Using ALARA in this way prevents owners from re-remediating once laboratory sample results are received. This practice has been documented by the Department of Energy and the USEPA in decision documents related to remediation of Superfund sites with radioactively contaminated soil.

30. COMMENT: One commenter stated that the Department contradicts itself when it states that the rule does not contain any standards or requirements that exceed the standards or requirements imposed by Federal Law and also that it is impossible to determine if USNRC's standards are more or less stringent than the proposed standards. (3)

RESPONSE: Based on the model comparisons performed, the Department believes that the rule does not contain any standards or requirements that exceed the standards or requirements imposed by Federal Law.

31. COMMENT: One commenter suggested that the example regarding radioactivity measurement variations suggests that other than 95 percent confidence is obtained at two standard deviations. (6)

RESPONSE: The Department reevaluated this paragraph and finds no reference to standard deviation. The Department only states that uncertainty is reported as a 95 percent confidence interval. In order to clarify this, the Department has added ± 2 standard deviations in parenthesis. However, the commenter should realize that this discussion is not related to the Department's use of one standard deviation to determine acceptable background.

32. COMMENT: Two commenters disagreed with the Department's statement that the USEPA's 40 CFR 192 does not address vertical extent. (6, 5)

RESPONSE: While 40 CFR 192 does address remediation standards based on thickness of the contaminated zone, the USEPA Directive No. 9200.4-25, which is applied when the radioactive contamination at a site is unlike that at a uranium mill tailing site, does not specifically address vertical extent. It merely states that 5 pCi/g is a suitable cleanup level for subsurface

contamination, if a site-specific risk assessment demonstrates that 5 pCi/g is protective.

33. COMMENT: One commenter stated that the USEPA's Directive 9200-4.25 states that the criteria for radium in soil in 40 CFR 192 are not only deemed fully protective of people and the environment, but they have also been deemed consistent with the USEPA's level of acceptable radiation dose (i.e. 15 mrem/y to the maximally-exposed individual). Therefore, in order for the proposed rule to remain consistent with existing federal (USEPA) standard, the release criteria for radium in soil should be equivalent to that shown in 40 CFR 192. (5)

RESPONSE: The above statement could not be located in USEPA's Directive 9200-4.25. In fact, Directive 9200-4.25 clearly states that when the radioactive contamination at a site is unlike that at a uranium mill tailing site, i.e. when significant quantities of moderate or low activity materials are involved (between 5 and 30 pCi/g), the use of the 15 pCi/g standard is not generally appropriate. Many of the sites in New Jersey have significant quantities of moderate or low activity materials in the subsurface. Also Directive 9200-4.25 clearly states that the concentration criterion for subsurface soil is not a health-based standard.

34. COMMENT: One commenter stated that USEPA's Directive 9200-4.18 "Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination" did not establish 15 mrem/y as "the acceptable annual dose that will meet the CERCLA risk range." This guidance reaffirms that "Cleanups of radionuclides are governed by the risk range for all carcinogens (radiological and nonradiological) established in the NCP when ARARs are not available or sufficiently protective." Thus cleanup of sites contaminated with radionuclides should achieve risk levels in the 10^{-4} to 10^{-6} risk range. Where a dose assessment is conducted at the site, the guidance states that "15 mrem/y effective dose equivalent should generally be the maximum dose limit for humans." The Federal Standards Statement, Comparison to EPA Regulations and Guidance Documents, should clarify the relationship between the CERCLA risk range (10^{-4} to 10^{-6}) and the proposed DEP dose standard, as well as compare the proposed rule with the requirements of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). (2)

RESPONSE: The Department agrees that the OSWER Directive reaffirms that cleanups

of radionuclides are governed by the risk range for all carcinogens established in the NCP and that 15 mrem/y effective dose equivalent should generally be the maximum dose limit for humans. The Federal Standards Statement has been revised to reflect this language.

35. COMMENT: One commenter requested a discussion of 10 CFR 40 Appendix A for Formerly Utilized Sites Remedial Action Program (FUSRAP) sites. Criteria 6 pertains to establishing benchmark doses for byproduct material containing radionuclides other than radium in soil, and surface activity on remaining structures. The total effective dose equivalent must not exceed the dose from cleanup of radium contaminated soil to the benchmark. (6)

RESPONSE: FUSRAP sites in New Jersey are also CERCLA sites under the jurisdiction of the USEPA. Any benchmark dose that is derived would have to comply with the National Contingency Plan (NCP) risk range of 10^{-4} to 10^{-6} . The relationship between 15 mrem/y and the NCP risk range is discussed in the Federal Standards Statement.

36. COMMENT: One commenter was concerned that the history of the Uranium Mill Tailings Radiation Control Act (UMTRCA) standards was not taken into account in the Federal Standards Statement section of the proposal. The USEPA regulation 40 CFR 192 does not state the 15 pCi/g for Ra-226 is just a measurement tool and the first standard of 5 pCi/g is to be applied and achieved to depth. (6)

RESPONSE: The commenter is correct that the promulgated EPA rule does not explicitly state that the 15 pCi/g subsurface standard was meant as a "finding tool" and that after remediation the levels would be 5 pCi/g or below throughout the soil column. However, this discussion is provided in the USEPA OSWER Directive No. 9200.4-25, which is discussed in the Federal Standards Statement.

37. COMMENT: One commenter states that the radiation dose basis in the rule proposal (15 mrem/y) is more restrictive than the federal (USNRC) dose basis for release of sites for unrestricted use (25 mrem/y) in 10 CFR 20 Subpart E, even though the Federal Standards Statement of the rule denies this fact. (5)

RESPONSE: Since cleanups are based on concentration of radioactive materials (pCi/g) and not dose (mrem/y), it is difficult to determine which standard is more restrictive. The

Department ran model comparisons between its spreadsheet, RaSoRS (Radiation Soil Remediation Standards) and the USNRC model, D&D (Decommissioning and Decontamination). The default values for D&D were used in both D&D and RaSoRS. The default values for RaSoRS were used in both D&D and RaSoRS. The results showed dose factors that are comparable. The dose factors ranged from 5.8 mrem/y per pCi/g to 6.8 mrem/yr per pCi/g. When the same comparison is done with Radium-226 the range is broader, but as expected, the NRC screening parameters result in more restrictive soil remediation standards. Because the NRC default values are more restrictive, a licensee is expected to adjust these parameters to be more realistic to determine the site-specific remediation standard. Since the Department cannot perform this next level of model comparisons without site-specific information, it is assumed that when this is taken into account, the Department and the USNRC's remediation standards will be comparable, meaning one will not be overly restrictive compared to the other.

38. COMMENT: One commenter stated that Federal Standards Statement states that it is not possible to compare the criteria in the proposed rule to USNRC requirements because the USNRC does not provide generic soil concentrations. The Department's statement is incorrect because the USNRC-approved computer code, entitled "RESRAD" is commonly used to convert maximum allowable doses (i.e., the 25 millirem per year deemed acceptable by the USNRC in 10 CFR 20) to soil release concentrations. In fact, the Department uses this same computer code throughout its own Technical Basis Document. (5)

RESPONSE: The USNRC allows RESRAD to be used, but also allows its own code D&D be used to convert dose to soil concentration. Comparisons of the Department's model with D&D are given in the response to comment number 36. The Department used some of the standard pathway equations that were used in RESRAD, but modified them to account for the mixing of the clean cover with the residually contaminated layer to account for construction of a slab or basement.

39. COMMENT: One commenter stated that in 10 CFR 40, "Radiological Criteria for License Termination of Uranium Recovery Facilities", the USNRC states that the release criteria for uranium, radium and thorium deemed acceptable by the USEPA in 40 CFR 192 will

satisfy the USNRC's requirements for release for unrestricted use. Therefore, in order for the proposed rule to remain consistent with existing federal (USNRC) standards, the release criteria for these radionuclides in soil should also be consistent with the criteria in 40 CFR 192. (5)

RESPONSE: No such reference could be located for the given citation. Also, there are no uranium recovery facilities, as defined by the USNRC, located in New Jersey.

Subchapter 12. Soil Remediation Standards for Radioactive Materials

N.J.A.C. 7:28-12.2

40. COMMENT: Three commenters expressed concern that as written, the regulation raises potential Federal preemption concerns. Pursuant to the Atomic Energy Act of 1954 (AEA), as amended, NRC has regulatory authority over the possession and use of special nuclear material, source material, and byproduct material, as defined in that Act, in order to protect the public health and safety. States may regulate some of these materials if they enter into an agreement with NRC pursuant to section 274 of the AEA. New Jersey has not entered into such an agreement.

In general, Congress has given NRC complete regulatory authority regarding radiation protection over the topics listed above. Accordingly, as a general matter, States are preempted from regulating such material for the purposes of radiation protection. However, issues of preemption and State jurisdiction must be made by the courts; the NRC does not have authority to issue final, legally binding decisions with regard to these issues.

In addition to the legal issues, New Jersey's regulations also raise practical concerns, for both power-reactor and materials facilities licensed by NRC. The impact of New Jersey's regulations on the implementation of NRC's regulatory program is unclear. Also, New Jersey's regulations have the potential to decrease the efficiency of regulation by requiring regulated entities to comply with two separate cleanup standards as well as potentially impede NRC licensees from terminating operations because of conflicting cleanup standards. In addition, NRC is concerned about the finality of NRC license terminations (i.e., it is unclear whether the State would attempt to require additional cleanup after license termination by NRC.) (3, 5, 8)

RESPONSE: The Department agrees that final decisions on preemption and

jurisdictional issues are made by the courts. The Department does not believe that the rule, as written and enforced by the Department, will be found to be pre-empted by NRC authority. Although the current NRC dose criterion of 25 mrem/yr does not meet the federal government's National Contingency Plan risk range regarding the remediation of Superfund sites, the actual soil concentration values currently used by the NRC would likely meet this risk range and thus New Jersey's criteria. Confirming this assumption are the latest screening values published by the NRC (Federal Register Vol. 64, No. 234, December 7, 1999). An NRC licensee meeting these values will also comply with New Jersey derived concentration guideline values for unrestricted use. There would be no need for the State to require additional remediation after meeting the NRC's criteria.

41. COMMENT: Two commenters were concerned that the proposed rule did not take into account material whose radioactive concentration has not been changed by physical or chemical processes, but whose exposure pathway to humans and the environment has been enhanced by human activity. (2, 6)

RESPONSE: The Department interprets physical activity to mean any human activity. But in order to make the rule clearer, the phrase "technologically enhanced" will replace the phrase "man-made physical or chemical activity" in N.J.A.C. 7:28-12.2(a)1 and N.J.A.C. 7:28-12.2(b)1. Definitions of "Technologically enhanced naturally occurring radioactive materials" and "Radioactive materials" have been added to the definition section.

42. COMMENT: One commenter questioned why CERCLA was not mentioned in N.J.A.C. 7:28-12.2(a)3 although it was mentioned in the summary. (6)

RESPONSE: Rather than mention CERCLA in N.J.A.C. 7:28-12.2(a)3, the Department believed it was important enough to warrant its own subsection at N.J.A.C. 7:28-12.2(c). It falls under the same section of the rule on applicability.

43. COMMENT: One commenter expressed concern that the State does not have the authority to regulate uranium or thorium (and therefore radium when its isotopes are in equilibrium with uranium and thorium) at concentrations above or below 0.05 percent as defined in 10 CFR 40.4. The commenter points to Section 62 of the Atomic Energy Act and 10 CFR

40.13(a) which exempts unimportant quantities of source material from NRC licensing. This section defines unimportant quantities of source material as less than one-twentieth of one percent by weight. (8)

RESPONSE: Unimportant quantities are exempt from US NRC licensing. The Department derives its authority to regulate naturally occurring and accelerator produced radioactive materials from the Radiation Protection Act. The Act also states that the Department has the authority to prevent exposure to unnecessary radiation.

44. COMMENT: One commenter requested that the proposed rule should be made inapplicable to any materials (in addition to coal ash) that can satisfy the three criteria set forth for exempting coal ash. (8)

RESPONSE: The reason coal ash can be broadly exempted (see N.J.A.C. 7:28-12.2(b)2) is because there have been numerous studies done on the concentrations of naturally occurring radioactive materials present in coal ash. The concentrations are such that its use in these applications would not cause an unacceptable risk to users of these products. The Department's experience has shown that concentrations of other materials would be problematic for such uses.

45. COMMENT: One commenter requested that in order to ensure consistency with the existing Solid Waste regulations, the Department modify the proposed rule to incorporate by reference the existing categorical beneficial use approvals contained in N.J.A.C. 7:26-1.7. This change would clarify the Department's intent – that this rule is not intended to limit the beneficial reuse of coal combustion by-products.

The commenter also asked the Department to modify the proposed rule to clarify that the proposed standards do not apply to beneficial reuse projects which have been approved by the Department pursuant to N.J.A.C. 7:26-1.7(g)5. This regulation requires parties proposing new beneficial reuse projects to seek Department approval prior to any proposed non-categorical beneficial reuse ensuring protection of public health and the environment.

The commenter also requested that the Department exempt from the scope of this rulemaking coal combustion by-products that are beneficially used as structural fill. (12)

RESPONSE: The Department believes that the rule does not limit the beneficial reuse of coal combustion products. The existing Solid Waste Regulation for the beneficial reuse of coal ash found at N.J.A.C. 7:26-1.7(g) is consistent with this rule. The Department did not incorporate by reference the Solid Waste regulations because future revisions to those regulations may approve a use that would not meet the Department's dose criteria. The Department disagrees that the proposed standards should not apply to beneficial reuse projects which have been approved by the Department pursuant to N.J.A.C. 7:26-1.7(g)5 since the outcome of that action would be unknown. The Department cannot exempt coal combustion by-products that are beneficially used as structural fill because it has not been provided with sufficient justification that use as fill would not pose an unacceptable dose to a resident.

46. COMMENT: One commenter was concerned that recent USEPA modeling efforts indicate that coal ash as a land fill cover may result in radiation doses that exceed USEPA acceptable risk ranges for radionuclides as well as the proposed rule's standards. Consequently, the coal ash exemption in section N.J.A.C. 7:28-12.2(b)iii should be removed from the rule. (2)

RESPONSE: The Department reviewed the modeling studies and determined that coal ash used as landfill cover did not present an unacceptable risk and met the Department's standard. The USEPA modeling effort assumed a house is built on a pile of coal ash sixteen feet deep. Landfill cover in New Jersey is typically spread six inches deep every ten feet. A landfill that is closed when it reaches a depth of 60 feet will contain a total of three feet of coal ash. The vertical extent available to be uncovered in a typical basement excavation would be only six inches. Modeling efforts by the Department show the dose and risk estimates to be acceptable using the USEPA assumption of coal ash radionuclide concentrations. The commenter should also note that fly ash (which contains the greater concentration of radionuclides) is excluded from use as daily and intermediate landfill cover as per the Solid Waste Regulations N.J.A.C. 7:26-2A.8, et seq.

N.J.A.C. 7:28-12.3

47. COMMENT: One commenter did not agree with the definition of "enhanced" because it only addresses increased radionuclide concentrations. The commenter states that the

proposed rule should be applicable to radionuclides whose concentration and/or radiation pathway to people and the environment has been enhanced by any human activity, including activities such as relocation of material already at high concentration. (2)

RESPONSE: The Department agrees that such materials must be cleaned up as well, but believes that the proposed rule did apply to such materials. The Department has clarified this issue via substitution of the defined term “technologically enhanced naturally occurring radioactive materials” for the term “enhanced”. The new definition will not change the applicability of the rule in actual practice.

48. COMMENT: One commenter did not agree with the definition of 'residual radionuclides' in that it differed from the Multi-Agency Radiation Site Survey and Investigation Manual definition. (8)

RESPONSE: The Department agrees with this comment and has clarified the definition of residual radionuclides to exclude background. The definition of residual is that which is remaining or left over. The original intent was to exclude background as is evident in the Tables of derived concentration guideline levels, which are all presented as concentrations above background. These would be the concentrations remaining after remediation. In view of the foregoing, modifying this definition upon adoption constitutes an appropriate clarification of the regulatory text.

49. COMMENT: Two commenters questioned the definition of "appropriate period of time" in that seven half-lives would not achieve the Department's intent because the radionuclides would decay to about one percent of the original concentration. An example was given that if a controlled site had 500 pCi/g of radium-228, after seven half-lives there would still be 5 pCi/g of radium-228 and thorium-228 in roughly 40 years. (6, 5)

RESPONSE: Since the Department would not approve alternative standards that include controls where failure of those controls would result in more than 100 mrem total annual effective dose equivalent, seven half-lives would be sufficient to discontinue controls. In other words, the Department would not approve leaving radionuclides at such high concentrations that one percent of those concentrations would not meet the 15 mrem/yr dose criteria.

50. COMMENT: Three commenters did not agree with the definition of "Uncontaminated Surface Soil". One commenter thought that placing a restriction on the material of 20 percent of the site background was unreasonable. They suggested that a regional 95 percent upper confidence limit of background would be appropriate. One commenter thought the definition was unclear and should be rewritten regarding the relationship to the residual radionuclide concentrations. (6, 5, 3)

RESPONSE: The Department agrees with these comments since background within a site can vary by more than 20 percent. Therefore, the Department has modified the definition of uncontaminated surface soil to mean soil whose average natural background radionuclide total concentrations are less than the limits for residual radionuclides, and cannot exceed the background established for the site by more than two standard deviations. Typical background concentrations for a site in New Jersey are on the order of 1 pCi/g for the naturally occurring radionuclides. A variation of 20% would allow a deviation of only 0.2 pCi/g. This is below the detection capability of the instrumentation used to measure concentration. In order to be more reasonable, and not to compromise the intent of the proposal, the Department has allowed a variation of 2 standard deviations. For a typical site in New Jersey, this means the concentration could vary by no more than 95% of the background established for the site. Background is determined by collecting a number of samples and obtaining the average. Background on a site can vary by a factor of 2-3, so a 95% variation in the average background concentration will not be out of the range of concentrations that are typical for the site. The change in average natural background radionuclide concentrations in uncontaminated surface soil permitted under the rule will not affect the ability of that soil to shield the public from the contaminated materials beneath it and will not affect the actual protective exposure standard of 15 mrem/yr established by the Department in the proposal. In view of the foregoing, modifying this definition upon adoption in response to comment constitutes an appropriate clarification of the regulatory text.

N.J.A.C. 7:28-12.5

51. COMMENT: Two commenters questioned the Department's high degree of specificity in the laboratory requirements. The USEPA stated that the federal agencies are

moving away from prescribing analytical methods to a performance based approach for method selection. One commenter stated that some of the methods prescribed in this section would not meet the necessary detection limit for demonstrating compliance with the release criteria for all possible sample types. (2, 5)

RESPONSE: The Department agrees in concept with these comments, and has been anticipating the federal government's release of the Multi-Agency Radiation Laboratory Analytical Protocols (MARLAP) Manual. Since the MARLAP Manual is not expected to be finalized until after adoption of this rule, the proposed laboratory provisions will be adopted. Once MARLAP is finalized, the Department will review the document and if it is determined that there are significant differences between it and the rule, an amendment to the rule will be proposed.

52. COMMENT: One commenter suggested that not all laboratories have computer-generated "result forms" nor do all laboratories have "calculation worksheets" (the Department may have chosen un-identified laboratory or software protocols that are not common throughout industry). (5)

RESPONSE: The Department agrees with the commenter and has include "if available" in the language of N.J.A.C. 7:28-12.5(b).

53. COMMENT: One commenter was not aware of any State of New Jersey certification program for radiological analysis. (5)

RESPONSE: The State of New Jersey does have a certification program for radiological analysis of radionuclides in water. It may be found at N.J.A.C. 7:18.

54. COMMENT: One commenter suggested that the requirement for laboratories to have participated in and passed a soil intercomparison analysis without specifying what radionuclides are to be intercompared or what the performance criteria should be, serves no technical or quality assurance purpose. (5)

RESPONSE: Because the Department does not have a certification program for radionuclide in soil analysis, it is prudent to request additional documentation that the laboratory is competent in analyzing soil samples. The Department agrees that the methods of interest should be part of the intercomparison and has clarified this language in the adoption. The

performance criteria are decided by the agency issuing the intercomparison, i.e. acceptable, warning, and not acceptable.

55. COMMENT: One commenter questioned the need for a supplemental guidance document when the recommendations of the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) would suffice. This commenter states that Chapter 12 of the Department's Field Sampling Procedures Manual provides little-to-no additional guidance beyond that which appears in MARSSIM. (5)

RESPONSE: The Department agrees that Chapter 12 of the Department's Field Sampling Procedures Manual does follow MARSSIM closely, but there are some differences, the most important of which are different area factors and how to deal with subsurface contamination. The Department also felt the MARSSIM was difficult to use and that a step by step guide was needed. Several commenters have agreed that the Department's sampling manual provides a clear, easy to use guide to MARSSIM.

56. COMMENT: One commenter suggested including minimal detectable activities (MDAs) with detection errors when reporting final results. This commenter also suggests reporting coordinates in an approved coordinate system, sample depths, (from original surfaces), sample identifiers, and other variables that may assist data interpretation. (6)

RESPONSE: The Department agrees that minimal detectable activities must be reported and added this provision in N.J.A.C. 7:28-12.5(a)3. This requirement allows the Department to determine if the instrument was capable of detecting the reported concentration. The data provided by this extremely minor reporting requirement would routinely be generated by the laboratory in its analysis. Therefore, no actual additional burden will be placed upon the regulated public. Without this information, the Department would have incomplete information and would not be able to make a determination as to whether or not the site met the Department's criteria. Detection errors on final results are already required under N.J.A.C. 7:28-12.5(a)1. The requirements for reporting coordinates, sample depth, etc. are included in the requirements of N.J.A.C. 7:26E, Technical Requirements for Site Remediation. The Department already requires compliance with the applicable section of the Technical Requirements for Site Remediation.

57. COMMENT: Two commenters noted that the Department's Field Sampling Procedures Manual, incorporated by reference at N.J.A.C. 7:12.5(e), is strongly based on the federal MARSSIM guidance; however modification to the MARSSIM guidance is necessary where the variability in natural radioactivity is high compared to the remediation standard. The commenters cite MARSSIM, which states:

Unique site-specific cases may arise that require a modified approach beyond what is presently described in MARSSIM. This includes examples such as: 1) the release of sites contaminated with naturally occurring radionuclides in which the concentrations corresponding to release criteria are close to the variability of the background and 2) sites where a reference background can not be established.

Site characterization and final status surveys at sites with natural mineralization or heavy mineral deposits will require substantial changes to the Department's Field Sampling Procedures Manual. Because the maximum allowable concentrations of most of these radionuclides would be only a fraction of the background concentration, it would not be possible, using the industry-standard survey methods that appear in the MARSSIM document, to demonstrate compliance with these criteria for common mixtures of thorium and uranium. (8, 5)

RESPONSE: The Department agrees that in some cases, it may be difficult to distinguish background from areas that contain residual radioactivity when the remediation standards are small compared to the variability in background. For this reason, the Department has amended the Field Sampling Procedures Manual at Chapter 12, Section F, to reference NUREG 1505, *A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys*. Scenario B in NUREG 1505 addresses this issue adequately. The Department disagrees that substantial changes to the manual are needed.

N.J.A.C. 7:28-12.8

58. COMMENT: One commenter wanted clarification on whether the background concentration of radon is for indoor or outdoor radon. If it is indoor radon, there may be situations where the structure will exceed the level at which USEPA recommends citizens take

action to reduce radon risk. The proposed rule should limit radon (including background) to four pCi/L, consistent with EPA guidance and New Jersey's indoor radon program, as well as require radon-resistant techniques for new construction. (2)

RESPONSE: The acceptable incremental concentration above background is for indoor air. The Department agrees with the commenter that in areas where there is naturally occurring high levels of indoor radon, adding 3 pCi/L would result in radon concentrations that are over the USEPA and New Jersey guidance level of 4 pCi/L of radon for indoor air. However, these areas are most likely located in Tier 1 areas where radon-resistant construction techniques are already required for new construction. The Department also believes that enough conservatism was built into the modeling to minimize a situation such as described by the commenter. However, the Department will monitor the effect on indoor radon and may amend the rule at a later date if necessary.

59. COMMENT: One commenter was unsure of the approach that New Jersey used in establishing the exposure scenarios and receptors: average person, average member of the critical group, maximally exposed individual, or reasonably maximally exposed individual. (3)

RESPONSE: The Department took its direction from the Brownfield and Contaminated Site Remediation Act, specifically, N.J.S.A. 58:10B-12, which requires that the standards be based upon reasonable assumptions of exposure scenarios as to amounts of contaminant to which humans or other receptors will be exposed, when and where those exposures will occur, and the amount of that exposure; and to avoid the use of redundant conservative assumptions. The Department selected parameters based on the average member of the critical group. The critical group is the resident who consumes food grown from a garden on-site and drinks water from a well on-site. For the development of generic standards, the Department believes that this critical group is the reasonable exposure scenario for New Jersey. Also, the Department and the NRC used the same Dose Conversion Factors, those from EPA Federal Guidance No. 11 and 12.

60. COMMENT: One commenter believes that the rule raises concerns by proposing a separate groundwater standard, rather than using an all-pathways approach that includes the groundwater pathway as recommended by both national and international organizations. The

commenter notes that if New Jersey adopts an all-pathways standard, then the State should not require remediation of contaminated groundwater to USEPA Maximum Contaminant Levels (MCLs), and Sections 7:28-12.8(a)(3) and 7:28-12.10(a)(3) should be deleted from the proposed rule.

The proposed standards in 7:28-12.8(a)(3) require remediation of contaminated groundwater to MCLs. If the groundwater quality standards were not considered in establishing the soil concentration limits, the proposed standards could result in different groundwater standards being applied for remediation as opposed to what would be applied to protecting groundwater from residual contamination in soils. This problem could be averted if New Jersey adopted an all-pathways standard and eliminated the requirement to remediate contaminated groundwater to MCLs.

Given that the transport of radioactivity through ground water is included as an exposure pathway in developing the soil concentration limits, the commenter believes that additional protection for the groundwater pathway (by also limiting radionuclide concentrations in groundwater) is unwarranted. (3)

RESPONSE: The Department agrees that an all-pathways approach to soil remediation standards is the appropriate methodology. A change is made on adoption to N.J.A.C. 7:28-12.8(a)1 to clarify this point. However, the Department is not in a position to allow the violation of the New Jersey Ground Water Quality Standards (N.J.A.C. 7:9-6), therefore, the Department cannot eliminate the requirement to remediate contaminated groundwater to Maximum Contaminant Levels (MCLs). For the naturally occurring radioactive materials, the all-pathways approach limited the concentration of these nuclides in soil so that the current USEPA MCLs were not exceeded in one thousand years.

61. COMMENT: One commenter requested clarification that groundwater that is currently not contaminated above New Jersey Groundwater Quality Standards would be protected against future exceedences of groundwater standards. In addition, the preface should discuss in more detail the pathways evaluated in developing the soil remediation standards to assure that air (in addition to radon) and water pathways (surface and groundwater) were

adequately considered. (2)

RESPONSE: The Department believes that the all pathways approach for determining the remediation standards will prevent any exceedences of the USEPA MCLs due to the process of dilution, decay, and transport in nature as the radionuclides move through the aquifer. The pathway analysis is discussed in detail in the Technical Basis Document.

62. COMMENT: One commenter expressed concern that the dose from breathing indoor radon at the allowed incremental concentration is an order of magnitude higher than the 15 mrem/y basic dose limit. (3)

RESPONSE: The Department agrees with the commenter. The USEPA's guideline of 4 pCi/L is not a health-based standard, but is based on the best available technology to remediate elevated radon in indoor air.

63. COMMENT: Two commenters expressed opposition to the fact that the radon dose criterion was based on an indoor radon concentration increment of 3 pCi/L rather than on the dose equivalent from inhalation of 3 pCi/L. If the rule seeks to establish a dose-based standard then such standard should be expressed in units of dose received from all radionuclides under consideration. The commenter states that since the Department finds the dose acceptable from breathing this concentration of radon daily for the entire day, then a more lenient standard should be applied for a restricted use standard where the potential exposure time is lower. (4, 10)

RESPONSE: Whether the allowed radon increment is based on air concentration or dose would not change the remediation standards because they are based on a variation of background as per legislative direction in the Brownfield and Contaminated Site Remediation Act. The legislation did not require a dose-based standard, rather one that is consistent with regional background levels. The Department considered using a more lenient radon standard for commercial/industrial uses based on a reduced occupancy but disregarded it based on the USEPA recommendations. The USEPA's guideline of 4 pCi/L is not a health-based guideline, but takes into account the best available technology to remediate elevated radon in indoor air.

64. COMMENT: Two commenters expressed concern that the radon-based radium-226 standard was extremely limiting given the uncertainties in future building construction. One

commenter supports a variance from the radon-based radium-226 soil standard when the future land use is expected to be commercial/industrial. The variance should provide for the evaluation of the characteristics of the buildings that are planned for the site. The commenter suggests that the potential for radon intrusion should consider structure specific factors. In addition, the commenter believes that the radon-based standard should be waived when potential for intrusion cannot be predicted because there is no consensus that there exists wide-spread potential for radon intrusion problems in commercial buildings and that a radon intrusion problem can be mitigated by means that are more cost-effective than remediating soil. The proposed rule does not appear to allow such considerations. (4, 6)

RESPONSE: The proposed rule allows owners to propose alternate soil remediation standards based on site-specific factors and/or engineering and institutional controls. A radon remediation system is considered an engineering control. If radon is controlled, the dose-based radium-226 soil remediation standard would apply.

65. COMMENT: Two commenters requested a clarification as to measurement of indoor or outdoor radon concentrations regarding whether this includes background and only applies to radon-222. (5, 6)

RESPONSE: The radon criterion is an increment of background and only applies to radon-222. N.J.A.C. 7:28-12.8(a) has been revised to include these clarifications.

66. COMMENT: One commenter expressed concern that the standard deviation for radon was incorrectly calculated within the development document. The value of 3 was actually the geometric standard deviation and this value has no units although it was incorrectly assigned units of pCi/L. The geometric standard deviation cannot be interpreted as an arithmetic standard deviation and the 3.0 pCi/L limit established in this way is inconsistent with the methodology described. The estimate for indoor radon underestimates the arithmetic standard deviation. (8)

RESPONSE: The geometric mean was calculated by taking the natural log of each data point and taking the average. The anti-log of this average is termed the geometric mean. The standard deviation of the natural logs is then calculated. The anti-log of this value is termed the geometric standard deviation. The units are pCi/L for both the geometric mean and the geometric standard

deviation. The Department believes the values were determined correctly.

N.J.A.C. 7:28-12.9

67. COMMENT: Two commenters pointed out a typographical error in Table 3A for Ac227 USS2 VE1. The value should be 22, not 122. (3, 2)

RESPONSE: The commenters were correct in that the value should have been 22 instead of 122 in the proposal. The value has been replaced with 18 in keeping with the changes that resulted from parameter value updates discussed in comment number 102.

68. COMMENT: One commenter strongly questioned the technical basis for the steadily decreasing release criteria "at depth" in soil, since, for the radionuclides in question, the risk to potentially exposed populations from the direct exposure, radon, and groundwater pathways *decreases* with increasing soil cover. (5)

RESPONSE: This commenter has misinterpreted the tables. Vertical Extent refers to the thickness of the contaminated zone, not how deep it is. A vertical extent of 5 means that the contaminated zone is 5 feet thick. The tables correctly depict the risk to potentially exposed populations decreasing with increasing soil cover (Uncontaminated Surface Soil).

69. COMMENT: One commenter questioned why radium-226 is excluded from the unity rule in Tables 1A through 3B. (5)

RESPONSE: The sum of the fraction calculation is done so that the total dose from all nuclides present on the site will not exceed 15 mrem/y. The standards presented in Tables 1A-3B for radium-226 are limited by the radon increment. Appendix A presents the soil standards for radium-226 based on the gamma and intake exposure pathways. It would not be fair to use a radon-based standard for a sum of the fractions calculation since it is more restrictive than the dose-based standard. However, after the sum of the fraction calculation is performed, the owner is required to use whatever radium-226 standard is more restrictive for the clean-up.

70. COMMENT: One commenter expressed concern that it would be impossible for the release criteria shown in the various tables to be met (or demonstrated to be met) if more than one of the radionuclides in question is present at a site. It is common to have mixtures of radionuclides at sites of natural uranium and natural

thorium. (Virtually every back yard in the State of New Jersey has mixtures of the same radionuclides that are in the Department's tables.) For common mixtures of uranium and thorium, with progeny in general equilibrium, in order to demonstrate compliance with the unity rule in N.J.A.C. 7:28-12.9(a)(2), the unrestricted release criterion for each of the radionuclides in Tables 1A and 1B, can be only one-sixth of the concentrations shown in the table. This assumes that the contribution of other dosimetrically-significant isotopes in the thorium and uranium decay series can be ignored, as is implied by their omission from the tables. (5)

RESPONSE: The comment illustrates this point with the most restrictive criteria presented in the proposal. The Department acknowledges the fact that at many sites more than one nuclide is present and that it would be difficult and expensive to remediate to the required levels. That is why allowance is given for engineering and institutional controls and also for the addition of clean cover. The contribution from the other progeny are taken into consideration by assuming secular equilibrium as outlined in the Technical Basis document. They are not ignored.

71. COMMENT: One commenter expressed concern that that a site with uncontaminated surface soil greater than five feet would be required to apply for an alternate remediation standard. (6)

RESPONSE: The Tables do not to limit the amount of clean cover to five feet. If a person responsible for remediating a site wishes to use more than five feet of cover, an alternate remediation standard would not be required. The Department's spreadsheet RaSoRS allows inputs of over five feet of cover, as well as vertical extents greater than nine feet.

72. COMMENT: One commenter was concerned that the tables in N.J.A.C. 7:28-12.9 (a) and (b) were inconsistent. An example was given for Th-232 that showed the backcalculated number and the unrestricted number were both supposed to result in 15 mrem/y, but did not. (6)

RESPONSE: The commenter is correct in that both numbers should result in 15

mrem/yr. In the example given, there was an error in the backcalculated number for Th-232 in Table 4A and 4B in the proposal. Since some of the parameter values have been changed (see Comment number 102), the values have been replaced. The methodology used to backcalculate these numbers did not change, however. This is done by determining the dilution factor (the vertical extent divided by the total depth - contaminated layer plus uncontaminated surface soil) and multiplying that value by the concentration that would result in 15 mrem/y if the soil were not mixed. This value is entered into the Department's spreadsheet, RaSoRS, along with 0 as the amount of uncontaminated surface soil and the total depth of the mixed material as the vertical extent. If the resultant dose is over 15 mrem/y, the spreadsheet's capabilities are used to calculate what value will result in 15 mrem/y (by using the Tools/Goal/Seek option). Once that number is obtained, it is multiplied by the inverse of the dilution factor to obtain the value that can be left after remediation, but before mixing. The reason for the backcalculations is given in the response to comment number 86.

73. COMMENT: Four commenters expressed opposition to the Department's allowing mixing of clean soil with residually contaminated soil as a means to achieve remedial goals. All opposed the spreading of contamination onto areas that are not contaminated. (2, 3, 11, 7)

RESPONSE: As explained in the response to comment number 11, the Department agrees that the blending, mixing, and/or dispersion of non-native soil contaminated with radioactive materials to achieve remedial goals should not be done. The mixing in N.J.A.C. 7:28-12.9(b) has a history which warrants an explanation. In its original interested party draft, the Department proposed soil remediation standards based upon the thickness of the contaminated zone and the amount of clean cover placed over the contaminated zone. The resultant doses were calculated based on the assumption that the site would eventually be disturbed by constructing a basement or a slab. The assumption was that during construction, the contaminated soil would be mixed with the clean soil so that a less concentrated zone would now be on the surface. This assumption

is currently being employed by the USNRC and the US Department of Energy in their dose assessments. This assumption was not questioned by any of the federal agencies during the interested party review.

Through an internal review of the proposal, a situation was brought up whereby it might be possible that other types of construction activities, i.e. removal of soil for landscaping, may not result in the mixing of the contaminated zone with the clean cover, but might expose the more concentrated contaminated zone to the surface, thereby increasing the dose to a future resident above 15 mrem/y. To prevent this occurrence, the Department considered restricting all sites where clean cover was applied. However, this option would make it too difficult for owners to clean up to unrestricted use standards. Rather than require deed notices, the Department proposed a controlled mixing to simulate construction activities. This option was chosen for several reasons: 1) A deed notice to maintain the clean cover would not be required. If deed notices were used, the current owner of the property would be required to pay for the radiological analysis of the soil every time the soil was disturbed, to ensure it would meet the dose criterion. This did not seem to be equitable. 2) Instead of assuming when a basement or slab is constructed the soil is mixed properly, it would be demonstrated by the owner of the site before a No Further Action letter was issued. 3) There is an extra level of protection afforded by this controlled mixing in that in most cases the resulting dose is below 15 mrem/y. After mixing, all resultant doses would be 15 mrem/y or less. 4) The owner would be responsible for ensuring the concentrations are acceptable after mixing, before a site is released.

The commenters' main objection was mixing or blending in order to achieve remedial goals, and dispersing material onto uncontaminated areas. It is not the Department's intent to allow mixing to achieve the values in Tables 4A-5B. These values must be obtained by traditional remediation techniques (such as soil removal), and then the controlled mixing is required. The Department still believes that controlled mixing to simulate construction activities is preferable to releasing a site with the possibility of

exposing the more concentrated layer below the cover, thereby obtaining a greater dose.

74. COMMENT: One commenter requested clarification of the terms in the titles of Tables 4A, 4B, 5A, and 5B. (2)

RESPONSE: The definitions of uncontaminated surface soil and vertical extent are identical to those in N.J.A.C. 7:28-12.3, Definitions. The thickness of the residual radionuclide layer (vertical extent) and the thickness of uncontaminated surface soil (clean cover) must meet the values in the tables before mixing.

75. COMMENT: Three commenters wanted the Department to consider allowing methods to determine background radionuclide concentrations other than those presented in MARSSIM. (2, 6, 8)

RESPONSE: The Department agrees with this comment since the MARSSIM only addresses background in the context of the reference area for the final status survey. Background measurements may need to be taken in order to establish which non-parametric test can be used. Therefore, N.J.A.C. 7:28-12.9(a)3. has been revised to include reference to Chapter 12 of the Department's Field Sampling Procedures Manual.

76. COMMENT: One commenter stated that the availability of multiple standards for different contamination thicknesses should be useful to those cleaning up contaminated facilities. (3)

RESPONSE: The Department acknowledges the support for the proposal.

77. COMMENT: One commenter expressed concern that the tables providing allowable incremental concentrations of residual radionuclides in soil only include values for naturally occurring radionuclides. The rule also specifically applies to accelerator-produced residual radioactivity and apparently applies to all radionuclides, yet concentration limits for these other radionuclides are not included. In addition, concentration limits are not provided for Th-230, even though the Technical Basis Document (Section 1.1 and Table 1) indicates that Th-230 would be treated as a separate subchain of the U-238 series. (3)

RESPONSE: Although the proposal applies to all contaminants if applicability to the Industrial Site Recovery Act is established, tables for all nuclides were not included. The reason

for this is the impracticality of calculating soil remediation standards for over one hundred nuclides with the limited resources available to the Department. The Department has provided the acceptable dose criterion and acceptable parameters so that it will be easier to develop soil remediation standards than was the practice in the past, i.e. no dose criterion and no suggested parameter list. The soil remediation standards for Th-230 can be calculated using the Department's spreadsheet RaSoRS.

78. COMMENT: One commenter expressed concern that there are no requirements to consider doses from pathways not included in the analyses for the generic concentrations. However, the Summary of the proposed rule states that for some sites, licensees will need to do dose calculations for other possible uses of ground water, such as irrigation onto crops. The result of including additional exposure pathways would likely be the establishment of lower allowable concentrations than those published as generic. The Summary also states that the Department may need to include other pathways (irrigation) at certain sites but gives no guidance or criteria on when this will need to occur. Additionally, the rule does not provide any definitive information that the facility would need to provide to the State to allow the staff to make such a decision.

The commenter believes that the purpose of creating generic cleanup criteria is to provide concentrations that a site can use without (or with very limited) site-specific justification (i.e., to provide screening values). The whole process of requiring some undefined sites to do additional dose analysis to model pathways not included in the default calculations runs counter to this purpose and does not relieve any regulatory burden. Although NRC's screening approach is intended to be applicable to essentially all NRC-licensed facilities, the New Jersey generic concentrations appear to have more limitations in applicability. Thus, the commenter believes that the generic allowable concentrations proposed by New Jersey are not screening concentrations in the same sense as NRC's screening values. Thus, cleanup to meet New Jersey's generic allowable concentrations may not be acceptable for showing compliance with NRC's License Termination Rule (Part 20, Subpart E), without additional justification. (3)

RESPONSE: The Department's generic soil remediation standards are not meant to be used

in the same way as the US NRC screening values. It is the Department's understanding that the NRC screening values were developed using conservative parameters. Since the USNRC is responsible for sites across the United States, this approach makes sense. For example, the screening value for radium-226 is 0.6 pCi/g compared to the Department's generic value of 3 pCi/g (with 6 inches of vertical extent and no cover). If an NRC licensee meets the NRC screening value, no further remediation is necessary. If the site does not meet this value, then the owner of the site can use site-specific parameter values in the NRC model which would result in a higher remediation standard to demonstrate compliance with the NRC dose criterion. The Department's generic values may be used by any site in New Jersey without the need to do site-specific assessments, unless so desired. The Brownfield and Contaminated Site Remediation Act specifically directed the Department to avoid the use of redundantly conservative assumptions. It also required that the standards be based upon reasonable assumptions of exposure scenarios as to amounts of contaminants to which humans or other receptors will be exposed, when and where those exposures will occur, and the amount of that exposure. The Department was also directed to avoid the use of unrealistic conservative exposure parameters. The Department believes that for most sites, ingestion of crops irrigated with contaminated surface water, ingestion of fish from a contaminated surface water source, and ingestion of animal products grown on-site are not reasonable exposure assumptions. Most contaminated sites in New Jersey are located in areas where these exposure pathways would be unreasonable. If a site had a contaminated surface water source nearby, then the fish and irrigation pathways would be required. In addition, the Department is comfortable with the exclusion of these pathways because they add very little to the total dose for the naturally occurring radioactive materials.

79. COMMENT: One commenter expressed concern that New Jersey does not provide sufficient justification of the methodologies and assumptions for NRC to make a final conclusion that compliance with the proposed New Jersey rule would be sufficient to show compliance with NRC's License Termination Rule. The State should provide additional justification for its scenario and pathway descriptions, models, and parameter values used. (3)

RESPONSE: Additional justification for the scenario and pathway descriptions is

provided in the response to comment 78. Additional justification for the parameter values is provided under the Technical Basis Document responses under comment 2. The Department believes the Technical Basis document contains sufficient justification for its model.

80. COMMENT: One commenter stated that the Technical Basis Document states that two feet of clean cover is required. (6)

RESPONSE: The amounts of clean cover and thickness of the residually contaminated zone are as outlined in the tables. The Technical Basis Document does not state that two feet of clean cover is required.

81. COMMENT: One commenter stated that the uniform mixing will require excavation of the remaining contaminated soils and would negate the excavation cost savings applied to the cost comparison support of the proposal. (6)

RESPONSE: The majority of the cost is associated with the disposal of the radioactive material. The cost comparison used the Restricted Use standard which does not require uniform mixing.

82. COMMENT: One commenter expressed concern that the values in the tables are analogous to the Derived Concentration Guideline Levels (DCGL) in the Department's Field Sampling Procedures Manual but this is not stated in the rule. (8)

RESPONSE: The Department agrees with this comment. With the publication of MARSSIM, this terminology has become the standard. The Department has added DCGL to the definition section, as well as the Tables to be consistent with the Department's Field Sampling Manual and with MARSSIM.

83. COMMENT: One commenter expressed concern that the directions relative to footnote 3 to the Tables were unclear. (8)

RESPONSE: The Department agrees that a clarification is needed because the footnote was unclear. Footnote 3 has been clarified to explain that when more than one nuclide is present, the sum of the fractions calculation should use the values in Appendix A in the denominator (C_i) for radium-226 rather than the value in Tables 1A through 3B. After the allowed value for radium-226 is determined by using the sum of the fractions calculation, it is compared to the values in

Tables 1A through 3B. Whichever number is more restrictive is then used as the derived concentration guideline level. The same procedure is used if Tables 4A through 5B are being used, except Appendix B values are used for radium-226.

NJAC 7:28-12.9(a)2.

84. COMMENT: One commenter (8) thought that the sum of the fractions equation in the proposal was a simplification of the method to demonstrate compliance in the Department's Field Sampling Procedures Manual. The commenter outlined an approach that uses the sum of the fraction (1) as the DCGL. (8)

RESPONSE: The Department agrees that there are more ways to demonstrate compliance when the sum of the fractions is used. The method outlined by the commenter will be included in the Field Sampling Procedures Manual.

85. COMMENT: One commenter expressed concern that there were no Tables for Restricted Use under NJAC 7:28-12.9(b). (8)

RESPONSE: The Restricted Use DCGLs are given in Tables 3A and 3B. Restricted Use implies that a deed restriction will be issued to maintain the clean cover. There is no restriction required if the clean cover is mixed with the residually contaminated layer. Limited Restricted Use may be used for non-residential sites where only an institutional control is required. No maintenance of cover would be required.

86. COMMENT: Three commenters questioned the reasoning behind the values in the Tables that were backcalculated as indicated by an asterisk. (8, 6, 2)

RESPONSE: The Department's intention was to propose the rule without mixing as explained in comment number 72. After it was decided to ensure the greater level of protection by controlled mixing to simulate construction activities, the Department had to ensure that by mixing, the dose would still be 15 mrem/y or below. In some cases, (those values that are marked with an asterisk), after mixing, the dose was higher than 15 mrem/y. This is due largely to the fact that the major pathway for these nuclides (or their decay products) is the external gamma pathway or the crop ingestion pathway. Before mixing, it was possible that a portion of the gamma exposure was shielded by the cover; for the ingestion pathway, the root length did not penetrate

the contaminated zone, or only partially penetrated it. After mixing, the gamma exposure would increase slightly and the root would be totally immersed in a residually contaminated (although less concentrated) zone. Therefore, the Department's spreadsheet was used to ensure that the total dose was 15 mrem/y and these values were lowered. This was also done for the values in Appendix B.

87. COMMENT: One commenter expressed difficulty in understanding why the values in the Tables for Radium-226 are the same regardless of the use (unrestricted or limited restricted) or whether the uncontaminated surface soil is mixed or not. (8)

RESPONSE: The values for Radium-226 are the same because radon inhalation is the limiting pathway. There is not a different radon guideline (as per the USEPA) for residential vs. non-residential properties. The radon calculations include a modifying factor to account for the thickness of the residually contaminated zone and the amount of clean cover.

88. COMMENT: One commenter suggested a quantitative target for what constitutes uniform mixing. (8)

RESPONSE: The Department agrees with this comment and has added a statement to N.J.A.C. 7:28-12.9(b) to consult the Department's Field Sampling Procedures Manual where this quantification statement is included in Section F.10.

89. COMMENT: One commenter expressed concern that there was no mechanism to update the values in the Tables as dose modeling criteria change. (1)

RESPONSE: The Department does not expect the dose modeling criteria to change on a routine basis. If the criteria changes significantly, the Department can amend the rule.

N.J.A.C. 7:28-12.10

90. COMMENT: One commenter remarked that the parameter values used in the analysis (i.e., Tables 6-9) were selected to be conservative, but not overly conservative. However, selecting parameters individually does not ensure conservatism in the analysis. In other words, incorporating a group of parameters that are conservative individually does not ensure that collectively the results will be conservative. To ensure conservatism in the analysis, the parameter values should be selected as a group, which allows their interdependence to be considered (e.g.,

through the use of Monte Carlo analyses). (3)

RESPONSE: As explained in comment number 77, the Department was directed to select reasonable values and not to be redundantly conservative, therefore, a Monte Carlo analysis in the commenter's context, is not necessary.

91. COMMENT: One commenter was concerned that no mention of the industrial worker scenario appeared in the proposal and recommended that the State establish additional concentration guidelines that address that scenario. (1)

RESPONSE: Industrial worker scenario parameters were used in the Technical Basis Document to develop the limited restricted use and restricted use remediation standards.

92. COMMENT: One commenter expressed concern about how the parameters in Tables 6 and 7 should be utilized in RESRAD (the Department of Energy's model) or some other model. This commenter also wanted a justification of where the parameter values were obtained. Another concern was the difficulty in estimating indoor radon from soil radium concentrations. (6)

RESPONSE: RESRAD is an acceptable computer model, although the Department would review the input parameters before the results would be accepted. The Department's spreadsheet RaSoRS could also be utilized to perform modeling for alternate standards. The Department has provided justification for all parameter values in the Technical Basis Document. The Department's spreadsheet (RaSoRS) uses a model that takes into account the thickness of the contaminated zone and may be utilized by persons responsible for remediating sites contaminated with radioactive materials. The Department's methodology for estimating indoor radon is outlined in Appendix A of the Technical Basis Document.

93. COMMENT: Section N.J.A.C. 7:28-12.10(d) implies changes (differences) in Tables 6 and 7 are allowed in a petition for alternate soil standards. This is inconsistent with N.J.A.C. 7:28-12.10(b) that explicitly excludes changing values within Tables 6 or 7 which, to the extent that good quality site specific data were available, makes little practical or technical sense. (8)

RESPONSE: The Department has corrected the inconsistency in these sections by removing indoor and outdoor occupancy times from Table 6 and revising N.J.A.C. 7:28-12-10(d) to allow

changes in indoor and outdoor occupancy times. The remaining values in Table 6 and 7 cannot be altered because these are parameter values that were chosen based on the current scientific literature. The values in Tables 8 and 9 are ideal candidates for site-specific data because the alternate data would be based on the natural geology of the area. Values in Table 6 and 7 would not be based on factors that would endure for the length of time the residual radionuclides would be present.

94. COMMENT: One commenter requested that the wording of N.J.A.C. 7:28-12.10(b) be changed so that if the disposal method was an engineered cell, pile, or other restricted structure, no occupancy would be permitted. (9)

RESPONSE: The Department allows changes in occupancy as per N.J.A.C. 7:28-12.10(c)4. There was an inconsistency between N.J.A.C. 7:28-12.10(b), which explicitly excluded changing values within Tables 6 or 7, and N.J.A.C. 7:28-12.10(d), which allowed changes in Tables 6 and 7. The Department removed indoor and outdoor occupancy times from Table 6 and revised N.J.A.C. 7:28-12.10 (d) to allow changes in indoor and outdoor occupancy times. Changes allowed include zero occupancy, as long as this is explicit in the deed notice and meets the requirements of N.J.A.C. 7:28-12.10 (e).

95. COMMENT: Two commenters questioned whether the Department had a list of acceptable computer models. (8, 6)

RESPONSE: Because of the possibility of the availability of new or revised models, the Department will make a determination on a case by case basis.

N.J.A.C. 7:28-12.10(e)

96. COMMENT: One commenter objected to the inclusion of a provision that if all institutional and engineering controls failed, the total effective dose equivalent must result in no more than 100 mrem/y because failure of engineering controls would mean that in the future, a person would build a house on the engineered site. Constructing a home on an engineered cell or pile does not seem reasonable. Such a requirement would in essence restrict the engineered pile to radium-226 concentrations in the 20 to 40 pCi/g range which is about the same as that found in lawn and garden fertilizer. Concentrations of several hundred pCi/g of radium or thorium occur

in a wide variety of materials and have been successfully contained in structures such as uranium mill tailings piles and FUSRAP sites such as that at Canonsburg, Pa. It would be a waste of resources to build an engineered solution and have it limited only to fertilizer-type levels of naturally occurring radioactivity. Perhaps an additional explanation of what constitutes a reasonable failure of engineered and administrative controls could be included in the regulations with some dispensation regarding the low prospect of homes being built on certain types of sites.

(9)

RESPONSE: The Department believes that since the half-life of the naturally occurring radionuclides is so long (thousands to billions of years), that it is reasonable to assume that engineering controls would fail and the site would be available for a future resident.

97. COMMENT: One commenter objected to the inclusion of the provision that if all institutional and engineering controls failed, the total effective dose equivalent must result in no more than 100 mrem/y for the following reasons: 1). According to the summary of the proposed rule, the "no controls" provision is taken from Nuclear Regulatory Commission (NRC) regulations at 10 CFR 20.1301. These NRC regulations, however, address potential exposures to members of the public at operating NRC-licensed facilities, rather than potential exposures at a site with soil contamination. Because operating NRC-licensed facilities are very different from most sites that may be subject to the proposed rules on remediation of radionuclide-contaminated soil, adoption of these NRC regulations in the proposed rule appears inappropriate.

2) Unlike most operating or terminating NRC-licensed facilities, remedial action at sites subject to Department regulation would likely involve not only radionuclide-contaminated soil but also chemical-contaminated soil and potentially other chemical-contaminated media (e.g., groundwater). For such sites, existing New Jersey (as well as federal) site remediation programs already address the use of institutional or engineering controls in remedial actions. These laws establish requirements for maintenance of institutional and engineering controls and for monitoring of such controls to ensure that they remain in place as needed for protection from both chemical- and radionuclide-contaminated media. They do not require remedies to be selected based on the assumption that all institutional and engineering controls at a site will fail. New

Jersey site remediation laws, including the 1997 Brownfield and Contaminated Site Remediation Act, and the 1993 Industrial Site Recovery Act, provide for the selection of remedial actions that are consistent with expected future land use at a site. Where such future land use is expected to be nonresidential (e.g., commercial/industrial land use), remedial actions may include institutional and engineering controls to ensure that future land use will remain consistent with the selected remediation standards. In establishing such remedial actions, there is no requirement to assume that all institutional and engineering controls at a site will fail. In fact, a requirement to base remediation standards on a no controls scenario would contradict existing provisions which allow remedial actions to be based on the expected future land use at a site. Similarly, federal site remediation programs (e.g., Superfund, RCRA corrective action) also encourage site-specific consideration of future land use in remedy selection and the use of institutional and engineering controls. These federal regulations and policies apply to both chemical- and radionuclide-contaminated sites. Where institutional or engineering controls are included in a remedy, federal regulations require that the effectiveness of such controls be monitored and evaluated no less frequently than every five years. However, there is no requirement to select a remedy on the basis that all institutional and engineering controls at a site will fail.

3) If the proposed rule must consider NRC regulations, it may wish to consider NRC regulations at 10 CFR 20.1403, which pertain to the termination of an NRC license under restricted conditions. The regulations at 20.1403(e) require residual radioactivity at a terminating NRC-licensed site to be reduced so that if institutional controls were no longer in effect, there is reasonable assurance that the total effective dose equivalent from residual radioactivity statistically distinguishable above background would not exceed either 100 mrem/year or 500 mrem/year. NRC allows the 500 mrem/year standard if, among other things, durable institutional controls are in place and the site is rechecked at least every 5 years to assure that institutional controls remain in place as necessary. For sites in New Jersey with both chemical- and radionuclide- contaminated soil, durable institutional controls and periodic rechecks at least every 5 years are already required if institutional or engineering controls are part of a remedy. Therefore, the NRC's 100 mrem/year criterion does not appear to have been intended for such

sites.

4) Because the potential health risk (cancer risk) from exposure to radionuclide-contaminated soil is similar to that from exposure to soil contaminated with chemical carcinogens (e.g., arsenic, beryllium, benzo(a)pyrene), the remediation of radionuclide-contaminated soil should be consistent with the remediation of soil contaminated with chemical carcinogens. The existing policies and rules governing the remediation of chemical-contaminated soil have not ignored the potential for institutional and engineering controls to become unreliable. They prevent this potential by establishing strong mechanisms for maintaining and checking the controls within an appropriate timeframe (e.g. The Brownfield and Contaminated Site Remediation Act, Section 18). These mechanisms make the no controls scenario unrealistic and inappropriate in remedial decisions regarding radionuclide-contaminated soil. Instead of the no controls scenario, the proposed rule should require the use of these same mechanisms for maintaining institutional or engineering controls that are part of remedies for radionuclide-contaminated soil. (4)

RESPONSE: While it is true that the cited section of the NRC regulations are applicable to operating NRC-licensed facilities, the NRC also uses 100 mrem/y in Subpart E- Radiological Criteria for License Termination as a no controls dose criterion. This no controls criterion was selected because international and national radiation protection organizations consider it protective of the public.

There are a number of mechanisms already in place that provide for the continues monitoring and maintenance of any remedial actions which include an engineering and/or institutional control. First, the Technical Requirements for Site Remediation require the person that is responsible for conducting the remediation to include it the remedial action workplan a "description and schedule for the maintenance and evaluation . . . of all engineering and institutional controls." N.J.A.C. 7:26E-6.2(a)18. Second, the Technical Requirements for Site Remediation also require the person responsible for conducting the remediation to maintain all engineering and institutional controls, to conduct periodic inspections of the controls, and to submit monitoring reports to the Department. See, N.J.A.C. 7:26E-6.4(g). Third, at the completion of the remedial action, the Department will issue a no further action letter that

includes a covenant not to sue pursuant to N.J.A.C. 7:26C–2.6. All covenants not to sue contain "a provision requiring the person [responsible for conducting the remediation], or any subsequent owner, lessee, or operator during that person's period of ownership, tenancy, or operation, to maintain those [engineering and institutional] controls, conduct periodic monitoring for compliance, and submit to the department, on a biennial basis, a certification that the engineering and institutional controls are being properly maintained and continue to be protective of public health and safety and of the environment." N.J.S.A. 58:10B-13a.(2)(a). Finally, each deed notice details the maintenance and monitoring requirements necessary to ensure that the remedial actions which included engineering and/or institutional controls remain protective and provides notice that the owner and any subsequent owner, lessee, or operator have the obligation to perform that maintenance and monitoring of the remedial action.

The NRC license termination rule does allow the total effective dose equivalent to go up to 500 mrem/y if all controls fail. The requirements to be allowed to use 500 mrem/y include a demonstration that further reductions in residual radioactivity are not technically achievable, would be prohibitively expensive, or would result in net public harm. There is also a rigorous financial assurance requirement. In addition, the NRC will not even allow a license to be terminated under restricted conditions unless it can demonstrate that further reductions in residual radioactivity would result in net public harm or were not being made because the residual levels associated with restricted conditions are as low as reasonably achievable. The licensee must also document in the License Termination Plan how the advice of individuals and institutions in the community who may be affected by the decommissioning has been sought and incorporated following analysis of that advice. As per the Brownfield and Contaminated Site Remediation Act, the Department does not require that conditions such as these be met before restricted use standards may be applied. Therefore, the Department is justified in not allowing greater than 100 mrem/y total effective dose equivalent if all controls were to fail. While it is true that the Brownfield Act does not specifically require that the assumption be made that all controls will fail in the future, it does specify that the Department must make a determination that the alternative remediation standards are protective of public health and safety. The Department believes that

public doses over 100 mrem/y would not be considered protective of human health and safety.

98. COMMENT: One commenter does not support the use of a 100 mrem/y effective dose equivalent in the event of failure of institutional or engineering controls, as a substitute for periodic reviews and a requirement for the reestablishment of the controls. The rule should require corrective actions when institutional or engineering controls fail and periodic inspections such as every five years. (2)

RESPONSE: The Technical Requirements for Site Remediation, N.J.A.C. 7:26E, require the person responsible for conducting the remediation, the owner at the time the remediation is conducted, and subsequent owners, lessees and operators, during that person's ownership, tenancy, or operation, to monitor and inspect all engineering and institutional controls that are part of a remedial action at a contaminated site. The Technical Requirements for Site Remediation also requires these persons to conduct periodic inspections of the controls, and to submit monitoring reports to the Department. See, N.J.A.C. 7:26E-6.4(g). At the completion of the remedial action, the Department issues a no further action letter that includes a covenant not to sue pursuant to N.J.A.C. 7:26C-2.6. All covenants not to sue contain "a provision requiring the person [responsible for conducting the remediation], or any subsequent owner, lessee, or operator during that person's period of ownership, tenancy, or operation, to maintain those [engineering and institutional] controls, conduct periodic monitoring for compliance, and submit to the department, on a biennial basis, a certification that the engineering and institutional controls are being properly maintained and continue to be protective of public health and safety and of the environment." N.J.S.A. 58:10B-13a.(2)(a). Furthermore, each deed notice details the maintenance and monitoring requirements necessary to ensure that the remedial actions which included engineering and/or institutional controls remain protective and provides notice that the owner and any subsequent owner, lessee, or operator have the obligation to perform that maintenance and monitoring of the remedial action. Finally, these same persons have an obligation to conduct any additional remediation and implement any additional remedial actions, that are necessary to correct any problems identified during the periodic inspections of the engineering and institutional controls.

N.J.A.C. 7:28-12.11

99. COMMENT: One commenter expressed concern that the proposed New Jersey requirements for cleanup of sites for limited restricted use and for restricted use are in some cases less stringent than those required under NRC's criteria of 10 CFR 20.1403. First, the New Jersey proposed standards do not include any eligibility test for a site to be considered for cleanup for restricted use. In contrast, the NRC criteria require that release for restricted use only be used when either further cleanup would result in net public or environmental harm or when the residual radioactivity levels associated with restricted conditions are already reduced ALARA.

Second, the requirements for the institutional and engineering controls are different. NRC's regulation requires that institutional controls are legally enforceable. The proposed New Jersey standard does not include this requirement. Third, NRC's regulation also requires that specific public involvement activities be performed. The New Jersey proposal does not include such requirements. There also are slight differences in the financial assurance requirements for the costs of implementing and maintaining engineering and institutional controls.

In addition, under the proposed New Jersey standards, the New Jersey Department of Environmental Protection is the entity responsible for determining the nature and duration of all engineering and institutional controls. Under NRC's regulations, this responsibility belongs to the site licensee. (3)

RESPONSE: The Technical Requirements (N.J.A.C. 7:26E-1 et seq.) and statute N.J.S.A. 58:10B address these issues. 1) The eligibility requirements for a site to be considered for cleanup for limited restricted or restricted use are outlined at N.J.A.C. 7:26E-5.1(e)1. through 5. 2) The enforceability of all institutional and engineering controls is provided by statute at N.J.S.A. 58:10B-13d. 3) The commenter is correct that there are not public notification requirements. 4) Since the commenter did not articulate the perceived differences in the financial assurance requirements for the costs of implementing and maintaining engineering and institutional controls, the Department is unable to respond any further on this part of the comment.

The responsibility for determining the nature and duration of all engineering and institutional controls belongs to the person responsible for conducting the remediation, but the Department must approve the use of all controls.

N.J.A.C. 7:28-12.13

100. COMMENT: One commenter suggested that this section would be a good place to reference MARSSIM. If the Department's Field Sampling Procedures Manual follows the guidance presented in MARSSIM then this section should state that fact. (6)

RESPONSE: The Department's Field Sampling Procedures Manual uses the methodology presented in MARSSIM. N.J.A.C. 7:28-12.13 has been revised to include language to that effect.

Technical Basis Document: Development of Generic Standards for Remediation of Radioactively Contaminated Soils in New Jersey

101. COMMENT: One commenter expressed concern that the dose assessment strategy for the proposed New Jersey standard excluded a few pathways from consideration for the intake scenario. The exclusions included: (1) the aquatic pathway (ingestion of aquatic foods, such as fish); (2) meat and milk pathways; and (3) crop irrigation. On a generic basis, the assessment disregarded the possible use of ground water for any purpose other than drinking water. The Technical Basis Document does not provide sufficient justification regarding why these alternate uses would be unreasonable to assume. NRC assesses these excluded pathways in its determinations of screening concentrations. Because of these excluded pathways, NRC staff cannot determine on a generic basis that implementation of the proposed New Jersey standards would meet the intent of NRC's criteria for license termination. (3)

RESPONSE: The Technical Basis Document has been revised to include a justification as to why these pathways were excluded. On a generic basis, not screening, the meat, milk, and fish pathways are insignificant for the naturally occurring radioactive nuclides. The average member of the critical group intake rate is not significant for the Northeast Region using the USEPA Exposure Factors Handbook. Although they were excluded in the determination of the generic remediation standards for the naturally occurring radionuclides, if the Department deems that

exclusion of any of these pathways for a particular site would not be protective, one or all of the pathways would then be required. This determination would include the nuclides and surrounding land use and population habits. For example, most of the contaminated sites in New Jersey are located in urban areas where local zoning prohibits the growing of meat and dairy-producing animals. If the zoning includes farming, then inclusion of these pathways would be required. The Department was required to develop generic remediation standards using reasonable exposure scenario assumptions.

102. COMMENT: One commenter was concerned that the State does not provide sufficient justification or the methodologies and assumptions for NRC to make a final conclusion that compliance with the proposed New Jersey rule would be sufficient to show compliance with NRC's License Termination Rule. The State should provide additional justification for its scenario and pathway descriptions, models, and parameter values used. (3)

RESPONSE: The Department agrees that more justification is needed for the parameter values used. The Department has changed the following parameter values based on updated information from the USEPA, USNRC, and other State and federal sources.

Lot Size: The average residential lot size has been updated based on information obtained from the New Jersey State Office of Planning and confirmed by the American Housing Survey for the United States. One quarter acre will be used for the residential lot size and two acres will be used for the commercial lot size. These parameters values are used in the Technical Basis Document.

Residential time spent indoors and outdoors on site were recalculated based on the latest edition of the USEPA Exposure Factors Handbook (Volume I – III, EPA/600/P-95/002Fc, August, 1997). Time spent indoors changed from 70 percent to 68 percent. Time spent outdoors changed from 5 percent to 8 percent. Although these parameter values were deleted from Table 6, the new values were used as input to calculate the derived concentration guideline values in Tables 1A through 5B of the rule.

The homegrown crop ingestion rate was changed from 14,235 g/yr to 17,136 g/yr based on the latest edition of the USEPA Exposure Factors Handbook.

The Commercial indoor and outdoor breathing rate were changed from 1.2 to 1.4 m³/hr based on

the data presented in draft NUREG 5512, Vol. 3, *Residual Radioactive Contamination From Decommissioning, Parameter Analysis*.

The Department used these updated parameters to update the remediation standards in Tables 1A through 5B, and Appendix A and B.

The changes made to the parameter values described above resulted in the decrease of many of the derived concentration guideline values. The differences between the proposed derived concentration guideline levels (DCGLs) and the DCGLs presented today are not drastic, in that none of them resulted in an order of magnitude change from the proposal. Since the Department made the Technical Basis Document available for comment, changes in some of these parameter values were expected. Further, the effect of the change on the regulated community will be minimal for the following reasons:

- 1) The person responsible for conducting the remediation may still propose alternative standards with institutional and/or engineering controls.
- 2) It has been the Department's experience that radiologically contaminated soil is usually present at levels one or two orders of magnitude above the unrestricted use standards. Therefore the slight lowering of some of the DCGLs will not have a significant impact on the regulated community.
- 3) It has been the Department's experience that contamination is typically present as a layer. When that layer is removed, background levels of naturally occurring radionuclides are remaining. Therefore for most sites, if a remediation were to be performed using the proposed DCGLs, using the DCGLs presented today would not likely result in a much greater volume of material being removed.
- 4) The use of the ALARA principal in the remediation support survey (see Response to Comment 29).

Moreover, the change in the DCGLs does not alter the relevant protective standard used by the Department of 15 mrem/yr. In view of the above, updating and modifying the regulatory text upon adoption constitutes an appropriate clarification of the rule, and does not affect the efficacy of the proposal.

All other parameter values used in the proposal were comparable to either USEPA or USNRC parameter values. The Department believes that the pathways and equations used to determine dose are described sufficiently in the Technical Basis Document.

103. COMMENT: One commenter expressed concern that the Technical Basis Document cites NRC references for parameter values. It is important to point out that these NRC parameter values have been largely updated or superceded. (3)

RESPONSE: The Department has updated its parameter values upon adoption in the Technical Basis Document based on the updated EPA Exposure Factors Handbook and the USNRC's NUREG 5512, Vol.3.

104. COMMENT: One commenter expressed concern that the Department's model did not include contributions to food concentrations from irrigating with contaminated groundwater, resuspension or rainsplash of surface soil onto the plant surfaces, nor does it address the potential for direct consumption of crops without washing or processing. (3)

RESPONSE: The Department believes that for generic remediation standards, these pathways are insignificant.

105. COMMENT: One commenter pointed out an error in the equation for the Vertical Extent Factor, VEF, in Section 3.3. In one component of the equation, the inequality operators are missing. (3)

RESPONSE: The Department could not locate this error.

106. COMMENT: One commenter expressed concern regarding the level of crop ingestion that New Jersey assumes for the intake scenario in that the levels are insufficiently supported. New Jersey used national averages rather than the values for home-grown intake of the Northeast region from EPA's Exposure Factors Handbook. (3)

RESPONSE: The Department agrees with the commenter and has adjusted the crop ingestion rate in the Technical Basis Document to be the seasonally adjusted consumer only homegrown intake rate for the Northeast taken from the EPA's Exposure Factors Handbook, August, 1997.

107. COMMENT: One commenter pointed out that the Technical Basis Document uses a Radon to soil Radium ratio of 1.5 pCi/L per pCi/g. The commenter believes that if this is

the case, the values for Ra-226 in the Table 1A for Vertical Extents of 1-4 feet would cause an exceedance of the Radon standard. (6)

RESPONSE: As explained in section 3.3 of the Technical Basis Document, the radon to radium ratio is modified by factors to account for the vertical extent of the radium contamination. The derivation of the Vertical Extent Factor and the Clean Layer Factor are explained in Appendix A to the Technical Basis Document.

Radiological Assessment (Chapter 12 of the DEP Field Sampling Procedures Manual)

108. COMMENT: Three commenters expressed support for Chapter 12 of the Department's Field Sampling Procedures Manual in that it provides an easy to read, simple guide to the performing surveys following (generally) the methods in MARSSIM; is well written and provides clear direction for applying the MARSSIM process; and is creative and potentially useful to a license holder or owner of a site contaminated with radioactive materials. (3, 13, and 1)

RESPONSE: The Department acknowledges those comments in support of Chapter 12 of the DEP Field Sampling Procedures Manual.

109. COMMENT: Two commenters identified an error in that the Department incorrectly identified the number of samples needed in each survey unit as N. (13, 3)

RESPONSE: The Department agrees with the comment. The error has been corrected in Section F.4.

110. COMMENT: One commenter expressed concern that the first paragraph in Section F. 4 describes the process for determining the number of samples needed for final status surveys in cases where a contaminant is present in background, but does not state that it applies to such cases only. (3)

RESPONSE: The Department agrees with this comment and has clarified Section F.4.

111. COMMENT: One commenter expressed concern that the last equation in Section F.5 differs from the equation in MARSSIM. In particular, the variable δ is described as the

average residual radioactivity concentration for all sample points, in the survey unit, that are outside the elevated area. The test in MARSSIM describing this equation (Equation 8-2 in MARSSIM) states that δ is the estimated average residual radioactivity concentration in the survey unit (i.e., not the concentration outside the elevated area). (3)

RESPONSE: The Department acknowledges that the description of δ is different, but took this definition from the USNRC's own draft Regulatory Guide DG-4006, Section 2.4. The Department has changed the definition of δ to be consistent with MARSSIM after discussions with the author of DG-4006 determined that there was an error in the USNRC definition.

112. COMMENT: Two commenters expressed concern for the Department's statement in Section F.7, that if the area exceeds the $DCGL_w$ by more than a factor of 2, then it should be remediated. Both commenters describe significant inconsistencies with the MARSSIM approach. First, arbitrarily requiring remedial actions for locations that exhibit residual radioactivity in excess of 2 times the $DCGL_w$ is not consistent with a dose-based rule. The net effect would be the remediation of contaminated areas with calculated doses less than 15 mrem/y. For an example, consider the 30 m² outdoor area factor provided in Table F.1 for U-238, which is 8.4. In this example, limiting this area to be no greater than 2 times the $DCGL_w$ in essence requires the user to remediate to level that is 4.2 times less than the proposed dose criterion of 15 mrem/y. Second, the sample size in Class 1 survey units may be increased above that required by the statistical tests because of the potential for small areas of elevated activity. The scan MDC and the area factors table for the particular radionuclide determines how many more samples may be required. Scan MDCs greater than the $DCGL_w$ requires the user to determine if the sample spacing (based on the statistical test needs) in the survey unit provides an area (and thus area factor) where the scan MDC is less than or equal to the corresponding $DCGL_{EMC}$ (which is given by the $DCGL_w$ times the area factor). In some cases this initial area factor will be greater than 2; hence, the survey design (that results from following MARSSIM guidance) will not be able to detect if any areas within the survey unit are greater than 2 times the $DCGL_w$. In other cases, the only way that the MARSSIM survey design can work in Class 1 areas for a given scan MDC is to increase the sample size until the average area bounded by samples is reduced, and the resultant

area factor is increased to the point where the scan MDC equals the $DCGL_{EMC}$. An area factor limit of 2 will severely impact users in those situations where the scan MDC is more than 2 times the $DCGL_w$. Therefore, the commenter recommends that this limitation on area factor magnitude be rescinded as it is overly restrictive and severely impacts survey designs; the ALARA principal should be used to identify those situations when it is reasonable to remediate residual radioactivity that is greater than the $DCGL_w$. (3, 13)

RESPONSE: The Department agrees with the commenters. The area factors for radium-226 given in MARSSIM could not be confirmed. Therefore, the Department, using the same methodology as outlined in MARSSIM using the RESRAD computer model, recalculated area factors for radium-226. The new values are smaller and have been incorporated in the Field Sampling Procedures Manual. In addition, the investigation levels have been revised to reflect MARSSIM methodology.

113. COMMENT: One commenter was concerned that Section C.5 of Chapter 12 states that for surveys of Class 1 survey units, triangular grids must be used. NRC staff agrees that triangular grids are more efficient, but it is unclear why their use is required. The MARSSIM approach allows the use of square or triangular grids. (3)

RESPONSE: The Department agrees that the MARSSIM approach allows the use of square or triangular grids. However, since MARSSIM is guidance only, the Department decided to adopt the triangular grids for Class 1 survey units in the Field Sampling Procedures Manual because they are more efficient, as stated in MARSSIM.

114. COMMENT: Two commenters were concerned how Section F.2 of Chapter 12 describes the determination of the relative shift (Δ/σ). This section recommends that if the relative shift exceeds 3, the lower bound of the gray region (LBGR) should be increased until the relative shift is less than or equal to 3. It is not clear why this guidance differs from that given in the MARSSIM (see the MARSSIM, page D-20). Without considering some of the detailed guidance provided by the MARSSIM, people following the New Jersey Field Sampling Procedures Manual may arbitrarily decrease the relative shift too far, and may thus end up performing excessive sampling (more sampling locations than would have been necessary). We

recommend that New Jersey guidance refer to the discussion in the MARSSIM. (3, 8)

RESPONSE: The Department agrees with the commenter, however, this language was taken directly from the USNRC's Draft Guidance 4006. Section F.2. of the Department's Field Sampling Procedures Manual has been revised to reflect the methodology given in MARSSIM Appendix D.

115. COMMENT: One commenter expressed an opinion that the Department may want to revise Figure 1 to include several important steps that have always occurred during the CERCLA process, but were not individually shown on the Remedial Response Process Flowchart. (6)

RESPONSE: The note at the bottom of Figure 1 directs the reader to MARSSIM Appendix F where this comparison between MARSSIM and CERCLA can be found.

116. COMMENT: One commenter was concerned that Section C.1 should have a discussion on when radionuclide contaminants are commingled with other CERCLA hazardous substances including situations that the soil may be a RCRA hazardous waste. If Chapter 12 is not the appropriate place for this discussion, the reader should be referred to a different Chapter. (6)

RESPONSE: The Department agrees that the reader should be referred. Section C. 1. of the Field Sampling Procedures Manual has been revised to include a referral statement.

117. COMMENT: Two commenters expressed concern that the MARSSIM methodologies could not be applied in situations where the DCGLs were close to the variability of background. This could be the case at sites with multiple radionuclides, and where unrestricted use standards are being implemented. (5, 8)

RESPONSE: The Department agrees with the commenters and has revised Section F. to include reference to Scenario B of NUREG 1505, A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys. Scenario B is used when the DCGLs are close to the variation in background.

118. COMMENT: One commenter was concerned about the difficulty in establishing isotopic ratios for radionuclides. Soil mechanics and isotopic mobility factors cannot only vary

substantially from site to site, but also can vary over the area of a given site. While conceptually establishing ratios for site contaminants seems effective, the practicality of establishing ratios is difficult. It is not unusual to have soil in a few square meters provide wild variations in concentration ratios. The issue then becomes how to establish an effective average concentration and over what area size can the average be applied. Furthermore, how many soil samples and at what depths should they be taken to establish an effective average for the site? Criteria recognizing the real world complexities in establishing DCGLs needs to be provided in as succinct a manner as possible to assist license holders with complex sites. (1)

RESPONSE: The Department agrees with the commenter. As stated, conditions can vary from site to site and within an area of a site. Criteria that works for one site may not be appropriate for another. Actual situations regarding the issues raised by the commenter will be gathered and analyzed and incorporated into the Field Sampling Procedures Manual.

119. COMMENT: One commenter expressed concern with Section F.4. in that the Department recommends the application of the most restrictive isotopes area factor as a guide for all isotopes at a given site. It is the commenter's experience that it is more appropriate to use a given area factor column and apply the unity rule to the isotopes in relation to the individual factor. If this is not done, isotopes with nearly inconsequential impact on dose could drive acceptable concentrations of the dominant isotopes to unnecessarily low remediation levels. (1)

RESPONSE: The Department disagrees with the commenter. Area factors that are small compared to other nuclides means that they have a greater consequence on dose. It is unclear how the unity rule would be applied in these situations.

120. COMMENT: One commenter noted that no examples of the application of $DCGL_{EMC}$ are provided in Chapter 12. Because of the complexity with applying these factors, examples should be provided to clarify this application. (1)

RESPONSE: The Department agrees with the commenter and has added an example to Section F.5.

121. COMMENT: One commenter expressed concern that the Sampling Manual indicates that the Type I error rate is set at 5 percent and is not negotiable. (8)

RESPONSE: The Department believes that a 5 percent chance of passing a site when it should actually fail is reasonable and sees no reason to raise this type of error rate. However, the Department will accept lower Type I error rates. Section F.3. has been revised to reflect this.

Summary of Changes Upon Adoption:

The Federal standards analysis was reworded to clarify the relationship between the 15 mrem/y dose criterion and the acceptable risk ranges specified in the National Contingency Plan. This clarification was based on comment #34 from the USEPA.

In N.J.A.C. 7:28-12.2(a)1 and N.J.A.C. 7:28-12.2(b)1, a new term, "technologically enhanced" was inserted in response to comment #41 on the meaning of man-made physical or chemical processes.

In N.J.A.C. 7:28-12.3, definitions of "derived concentration guideline levels" (#82), "technologically enhanced naturally occurring radioactive materials" (#41 and #47), and "radioactive materials" (#47) were added based on comments (the corresponding comment numbers are in parenthesis) received. Additionally, the previous definition of "enhanced" was deleted in response to comment #41. Amendments were made to several definitions in response to comments as follows, with the relevant comments noted in parenthesis: "residual radionuclides" (#48) and uncontaminated surface soil (#50).

In N.J.A.C. 7:28-12.5(a)3, minimum detectable activities was added to the radionuclide analysis report in response to comment #56.

In N.J.A.C. 7:28-12.5(b), the Department clarified that computer-generated result forms or laboratory calculation sheets should be provided if available in response to comment #52.

In N.J.A.C. 7:28-12.5(d), the Department clarified that the intercomparison analysis should include the methods of interest in response to comment #54.

In N.J.A.C. 7:28-12.8(a)1, the Department specified that the 15 mrem/y dose criterion included the groundwater pathway in response to comment #60.

In N.J.A.C. 7:28-12.8(a)2, the Department clarified that the allowed radon increment applies only to radon-222 in response to comment #65.

In N.J.A.C. 7:28-12.9 (a) and (b), the Department revised some of the remediation

standards in Tables 1A through 5B based on comments received regarding the Department's modeling parameters (comment #2 on the Technical Basis Document).

In N.J.A.C. 7:28-12.9 (a) and (b), the Department used the nomenclature, derived concentration guideline levels in the title of Tables 1A through 5B to be consistent with current federal guidance in response to comment # 82.

In N.J.A.C. 7:28-12.9 (a) and (b), the Department clarified footnote 3 in response to comment #83.

In N.J.A.C. 7:28-12.9(b)2, the Department references the Department's Field Sampling Procedures Manual for how to determine if uniform mixing is achieved in response to comment #88.

In N.J.A.C. 7:28-12.9(a)3, the Department clarified that natural background radionuclide concentration could be established as per the Department's Field Sampling Procedures Manual in response to comment #75.

In N.J.A.C. 7:28-12.10(a)3, the Department references N.J.A.C. 7:28-12.8(a)3 for consistency based on comments #60 and #61.

In N.J.A.C. 7:28-12.10(b), the Department revised Table 6 to include the revised crop ingestion rate (in response to comment #2 on the Technical Basis Document) and to correct an inconsistency as pointed out in comment #93.

In N.J.A.C. 7:28-12.10(d), the Department corrected an inconsistency as pointed out in comment #93.

In N.J.A.C. 7:28-12.13, the Department clarified that the Department's Sampling Manual follows the guidance provided in MARSSIM in response to comment #100.

In Appendix A and B, the Department revised the values in the tables based on comment #2 of the Technical Basis Document.

Federal Standards Statement

Executive Order No. 27 (1994) and P.L. 1995, c.65 require State agencies which adopt, readopt or amend State regulations that exceed any Federal standards or requirements to include in the rulemaking document a Federal standards analysis.

The only Federal rules that can in any way be compared to this proposal are the U.S. Nuclear Regulatory Commission's (NRC) 10 C.F.R. Part 20 Subpart E, "Radiological Criteria for License Termination" (although this NRC rule is not applicable to state-regulated naturally occurring or accelerator-produced radioactive materials), and the Environmental Protection Agency's (EPA) 40 C.F.R. Part 192, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings."

Comparison to 10 C.F.R. Part 20 Subpart E

There are four reasons why it is impossible to determine if the NRC standards are more or less stringent than the proposed standards.

- The NRC dose limit for license termination is 25 mrem per year, but soil remediation standards were not promulgated in these rules. Instead, the NRC has a process to determine a site-specific soil remediation number using a NRC dose model. In contrast, as required by the Brownfield and Contaminated Site Remediation Act, the proposed new rules develop generic soil remediation standards, expressed in picocuries per gram (pCi/g) of soil. Since the NRC rule does not contain concentration values, it is impossible to determine if one is more stringent than another.
- Furthermore, the NRC's final rule requires measures be taken to reduce doses to below 25 mrem/year by applying the concept that doses should be as low as reasonably achievable (ALARA). The proposed rules have no ALARA requirement, but are based on a 15 mrem/year dose standard. An examination of the methodology used by NRC to determine compliance with the ALARA limit shows that it is reasonable to assume that a 15 mrem/year dose standard would be achieved. The uncertainties due to modeling assumptions and measurement of radioactivity as described below would cause the person responsible for remediating a site to perform clean-up activities in a manner such that 15 mrem and 25 mrem with ALARA are virtually interchangeable. Therefore, the Federal rule and the State proposed rules can be considered to provide equivalent protection of public health.
- Some of the modeling assumptions used by the NRC that differ from those used by the Department include breathing rate, time spent indoors, time spent outdoors, amount of water

consumed per year, and the amount of home-grown vegetation consumed each year. In addition, the NRC includes some pathways that are not included in the Department's model such as ingestion of fish from a contaminated surface water source, ingestion of animal products grown on-site, and ingestion of plant products from gardens irrigated with contaminated groundwater. On a site-specific basis, if any of these pathways were deemed appropriate, the Department could require the development of standards that include one or more of these pathways in accordance with N.J.A.C. 7:28-12.4(b). Again, the only accurate way to determine which rule is more stringent would be to compare soil radionuclide concentration values. The NRC did not publish concentration values as part of its decommissioning rule.

- Radioactivity measurements are subject to a random variation arising from the nature of the radioactive decay process itself. The rate of radioactive decay is not a constant with time, but fluctuates randomly about a mean or expectation value. Although the true value can never be known exactly, limits to the uncertainty can be inferred and estimated from the measurement process itself. This uncertainty is usually reported as a 95 percent confidence interval ***(+ 2 standard deviations)***. Data are reported thus: 5 ± 1.2 pCi/g. This means that there is a 95 percent confidence that the true result is between 3.8 pCi/g and 6.2 pCi/g. Given this uncertainty in sample reporting, it is possible that the difference between a site-specific remediation standard for a NRC site and the proposed standard would be inconsequential because of the uncertainty in the analysis.

For example, assume that a site-specific NRC standard is determined to be 3.6 pCi/g and the proposed standard is 2.6 pCi/g. On the surface it appears that in this case, the proposed standard is more stringent than the NRC standard. However, when the samples are analyzed to show compliance, they are reported as 3.6 ± 0.8 pCi/g, 2.6 ± 0.4 pCi/g, 3.0 ± 0.6 pCi/g and 2.9 ± 0.5 pCi/g. Based on these reported results, one can conclude that there is a 95 percent confidence that the true value ranges from 2.2 to 4.4 pCi/g. Both standards are included within this range; therefore it can be said that the standards are equivalent. All the above uncertainties associated with modeling, sample analysis, and the radioactive decay process itself support the premise that the NRC dose limit of 25 mrem/yr cannot be directly compared to the proposed remediation

standards.

For the reasons stated above, a direct comparison of the NRC decommissioning rule and the proposed rule is impossible due to the lack of soil concentration standards under 10 C.F.R. Part 20 Subpart E.

Comparison to EPA regulations and Guidance Documents

The EPA regulation, 40 C.F.R. Part 192, was promulgated for specific use at either Federally or state-owned uranium or thorium mill tailing sites. The standard for applications involving unrestricted use is found in Subpart B. This standard is for radium-226 only and is summarized as follows:

Averaged over any 100 square meters, 5 pCi/g averaged over the first 15 centimeters (cm) of soil below the surface, and 15 pCi/g averaged over 15 cm thick layers of soil more than 15 cm below the surface. In any occupied or habitable building, a reasonable effort shall be made to achieve, an annual average radon decay product concentration (including background) not to exceed 0.02 Working Levels. In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. The level of gamma radiation shall not exceed the background level by more than 20 microrentgens per hour.

However, in 1983, when 40 CFR Part 192 was published, the basic radiation protection criteria for members of the public was 500 mrem/yr (five mSv/yr). It is now 100 mrem/yr (one mSv/yr) TEDE. As explained in USEPA Directive No. 9200.4-25 (signed 2/12/98), the 15 pCi/g standard is not a health-based standard, but rather was derived as a practical measurement tool for use in locating discrete caches of high activity tailings that were deposited in subsurface locations at mill sites or at vicinity properties. It was not developed for situations where significant quantities of moderate or low activity materials are involved. It is only appropriate for use, as a cost-effective tool to locate radioactive waste, when contaminating subsurface materials are of high activity and are not expected to be significantly admixed with clean soil. The Directive states that "if the radioactive contamination at the site is unlike that at the uranium mill tailings sites regulated under 40 CFR Part 192, in that significant subsurface contamination exists at a level between 5 pCi/g to 30 pCi/g, the use of the 15 pCi/g standard is not generally appropriate. In

this situation, we recommend 5 pCi/g as a suitable cleanup level for subsurface contamination, if a site-specific risk assessment demonstrates that 5 pCi/g is protective."

In Directive No. 9200.4-18 (signed August 20, 1997), the EPA reaffirms that cleanups of radionuclides are governed by the risk range for all carcinogens (radiological and nonradiological) established in the NCP when ARARs are not available or sufficiently protective. Cleanup of sites contaminated with radionuclides should achieve risk levels in the 10^{-4} to 10^{-6} risk range. Where a dose assessment is conducted at the site, the guidance states that 15 mrem/y effective dose equivalent should generally be the maximum dose limit for humans. This is the same requirement as is set forth in the proposed new rule at N.J.A.C. 7:28-12.8.

A direct comparison with 40 C.F.R. Part 192 cannot be made because when contamination at the site is unlike that at the uranium mill tailing sites, then OSWER Directive 9200.4-25 does not specify vertical extent of the remaining contamination or amount of uncontaminated surface soil. However, if a vertical extent of six inches and no uncontaminated surface soil is assumed, then the EPA rule and the proposed new rule would be the same. (The proposed rules would allow five pCi/g of radium-226 under these conditions.)

Therefore, based on the above analysis, the Department has determined that the proposed new rules do not contain any standards or requirements that exceed the standards or requirements imposed by Federal law to date. Accordingly, Executive Order 27 (1994) and P.L. 1995, c.65, do not require any further analysis.

Full text of the adoption follows (additions to proposal indicated in boldface with asterisks ***thus***, deletions from proposal indicated in brackets with asterisks *[thus]*):

SUBCHAPTER 12. REMEDIATION STANDARDS FOR RADIOACTIVE MATERIALS

7:28-12.1 Purpose and scope

The purpose of this subchapter is to establish minimum standards for the remediation of real property contaminated by radioactive materials. This subchapter also provides direction on remediating a site contaminated with radioactive materials with regard to sampling, surveying, and laboratory requirements, remedial action selection, and remedial action requirements.

7:28-12.2

Applicability

(a) The standards in this subchapter are applicable to:

1. Remediation of radioactive contamination of real property by any ***technologically enhanced*** naturally occurring *[radionuclide whose concentration has been enhanced by man-made physical or chemical processes]* ***radioactive materials***;

2. Remediation of radioactive contamination of real property by accelerator-produced radionuclides; and

3. Any other remediation of radioactive contamination including, without limitation, any remediation pursuant to: the Spill Compensation and Control Act, N.J.S.A. 58:10-23.11 et seq.; the Water Pollution Control Act, N.J.S.A. 58:10A-1 et seq.; the Industrial Site Recovery Act, N.J.S.A. 13:1K-6 et seq.; the Solid Waste Management Act, N.J.S.A. 13:1E-1 et seq.; the Comprehensive Regulated Medical Waste Management Act, N.J.S.A. 13:1E-48.1 et seq.; the Major Hazardous Waste Facilities Siting Act, N.J.S.A. 13:1E-49 et seq.; the Sanitary Landfill Facility Closure and Contingency Fund Act, N.J.S.A. 13:1E-100 et seq.; the Regional Low Level Radioactive Waste Disposal Facility Siting Act, N.J.S.A. 13:1E-177 et seq.; any law or regulation by which the State may compel a person to perform remediation activities; or N.J.A.C. 7:26C.

(b) The standards in this subchapter are not applicable to:

1. Materials containing naturally occurring radionuclides whose concentrations have not been ***technologically*** enhanced *[by man-made physical or chemical processes, such as coal or quarry stone]*; or

2. Coal ash that has been or is being used in:

- i. The manufacture of construction materials including, but not limited to, cinder blocks, concrete products and roofing materials;
- ii. Road construction materials including, but not limited to, asphalt filler or road base material; or
- iii. Landfill cover.

(c) The Department shall apply the radiation soil standards in this chapter at applicable sites as “Applicable or Relevant and Appropriate Requirements” as defined in the Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C. §§ 9601 et seq.

7:28-12.3 Definitions

The following words and terms, when used in this subchapter, shall have the following meanings, unless the context clearly indicates otherwise:

“Appropriate period of time” means the length of time required for the radionuclide to decay seven half-lives.

"Committed dose equivalent" means the total dose equivalent averaged throughout any body tissue in the 50 years after intake of a radionuclide into the body.

"Committed effective dose equivalent" means the sum of the products of the committed

dose equivalents to individual tissues resulting from an intake of a radionuclide multiplied by the appropriate weighting factor (W_T) indicated below:

Organ or Tissue	W_T
Gonads	0.25
Breast	0.15
Red bone marrow	0.12
Lung	0.12
Thyroid	0.03
Bone Surfaces	0.03
Remainder	0.30*
Whole Body (external)	1.00

*0.30 results from 0.06 for each of five "remainder" organs (excluding the skin and the lens of the eye) that receive the highest doses.

"Deep-dose equivalent" means, applied to external whole-body exposure, the dose equivalent at a tissue depth of one centimeter.

"Derived concentration guideline level" means the radionuclide-specific activity concentration corresponding to the release criterion.*

"Design features" means those features of a remediation that do not rely on additional expenditures after installation to achieve their intended purpose.

"Dose equivalent" means the product of the absorbed dose (D), the quality factor (Q), and other modifying factors (N). For the purposes of this definition, $N = 1$.

"Engineering controls" means any mechanism to contain or stabilize contamination or ensure the effectiveness of a remedial action. Engineering controls under this subchapter may include, without limitation, caps, covers, dikes, trenches, leachate collection systems, radon remediation systems, signs, fences and physical access controls.

["Enhanced" means raised to a higher concentration. For example, if the concentration of radium-226 in native soil was one pCi/g (0.04 Bq/g), and a physical or chemical separation process raised the concentration of radium-226 to two pCi/g (0.07 Bq/g), this would be considered "enhanced."]

"Final status survey" is a survey or analysis, performed after remediation, which provides data that demonstrates that all radiological parameters satisfy the remediation standards.

"Institutional controls" means a mechanism used to limit human activities at or near a contaminated site, or to ensure the effectiveness of the remedial action over time, when contaminants remain at a site in levels or concentrations above the applicable remediation standard that would allow unrestricted use of that property. Institutional controls under this subchapter may include, without limitation, structure, land and natural resource use restrictions, well restriction areas, classification exception areas, deed notices, and declarations of environmental restrictions.

"Intake dose" means the annual radiation dose to a person from all potential intake

pathways (exclusive of radon inhalation) including the ingestion of water, direct ingestion of soil, intake of foods, and the inhalation of resuspended particulate matter (in committed effective dose equivalent).

“Limited restricted-use remedial action” means any remedial action that requires the continued use of institutional controls but does not require the use of an engineering control.

"Natural background radionuclide concentration" means the average value of a particular radionuclide concentration in soils measured in areas in the vicinity of the site, in an area that has not been influenced by localized human activities, including the site's prior or current operations.

"Quality factor" means the factor by which absorbed doses are multiplied to obtain a quantity that expresses the effectiveness of the absorbed dose on a common scale for all types of ionizing radiation.

“Radioactive contamination or radioactive contaminant” means the collective amount of radiation emitted from one or more radionuclides in the soil at concentrations above natural background levels.

*****Radioactive materials" means any material, solid, liquid, or gas, that emits radiation spontaneously.***

"Radionuclide" means a type of atom that spontaneously undergoes radioactive decay.

"Regional natural background variation" means the best Department estimate, based on available data, of a region's naturally experienced variation in radiation dose from mean levels that are commonly and consistently experienced by persons in the State.

“Remedial action” means those actions taken at a site, or offsite if a radioactive contaminant has migrated or is migrating there from a radioactively contaminated site as may be required by the Department, including, without limitation, removal, treatment, containment, transportation, securing, or other engineering or treatment measures, whether to an unrestricted use or otherwise, designed to ensure that any discharged radioactive contaminant at the site, or that has migrated or is migrating from the site, is remediated in compliance with the applicable remediation standards in this subchapter.

“Remediation” or “remediate” means all necessary actions to investigate and cleanup or respond to any known, suspected, or threatened discharge of radioactive contaminants, including, as necessary, the preliminary assessment, site investigation, remedial investigation, and remedial action.

“Remediation standards” means the combination of numeric standards that establish a level or concentration, and narrative standards, to which radioactive contaminants must be treated, removed or otherwise cleaned for soil, ground water or surface water, as provided by the Department pursuant to N.J.S.A. 58:10B-12, in order to meet the health risk or environmental standards.

"Residual radionuclides" means the concentration of radionuclides remaining after the remediation is successfully completed *, **excluding background***.

"Restricted use remedial action" means any remedial action that requires the continued use of engineering and institutional controls in order to meet the established health risk or environmental standards.

*****Technologically enhanced naturally occurring radioactive materials" are any**

naturally occurring radioactive materials whose radionuclide concentrations or potential for human exposure have been increased by any human activities.*

"Total effective dose equivalent" means the sum of the deep- dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

"Uncontaminated surface soil" means soil whose average natural background radionuclide ***total*** concentrations are less than the ***[concentrations of the]* *limits for*** residual radionuclides, and cannot exceed the background established for the site by more than ***[20 percent]* *two standard deviations***.

"Unrestricted use remedial action" means any remedial action that does not require the continued use of engineering or institutional controls in order to meet the established standards.

"Vertical extent" means the average depth, measured in feet, of the post-remediation radioactive contamination over an affected area.

7:28-12.4 General requirements

(a) Any person conducting remediation pursuant to this subchapter shall comply with the requirements of N.J.A.C. 7:26E, Technical Requirements for Site Remediation, excluding those sections related to sampling, surveying, and background investigations. Sampling, surveying and laboratory requirements shall be in accordance with N.J.A.C. 7:28-12.5.

(b) Compliance with this subchapter shall not relieve any person from complying with more stringent cleanup standards or provisions imposed by any other applicable statute, rule or regulation.

7:28-12.5 Sampling, surveying and laboratory requirements

(a) Facilities licensed under 10 C.F.R. Part 50 that have Nuclear Regulatory Commission-approved quality assurance plans, are exempt from the requirements of this section. Otherwise, in addition to the requirements in N.J.A.C. 7:26E Appendix A IV.1, persons responsible for conducting remediations shall include the following in the radionuclide analysis reports:

1. Report final results as a value plus or minus the associated error for each sample;
2. Report data as calculated, and not report "less than" values for any sample;

3. Report minimum detectable activities;

***[3]**4*.** Calculate results for single sample and composites to the sample collection period mid point;

***[4]**5*.** Provide a quantitation report; and

***[5]**6*.** Provide copies of the instrument run logs.

(b) ***[As appropriate]* *If available***, persons responsible for conducting remediations shall provide:

1. The Gamma Spectroscopy Report which includes sample specific header information, peak search, peak identification, background subtraction, activity, and minimum detectable activity;

2. The Gross Beta calculation worksheets and computer generated result forms;

3. Radiochemical Iodine calculation worksheets and computer generated result

forms;

4. Liquid Scintillation calculation worksheets and computer-generated result forms;
and

5. Gross Alpha and Gross Beta, radium-226, uranium, and strontium-89 and 90 calculation worksheets and computer-generated result forms.

(c) For radionuclides, analytical methods contained in the following publications, incorporated herein by reference, or equivalents as approved by the Department, shall be used for determining radionuclide concentrations and/or radiation levels:

1. U.S. Environmental Protection Agency; "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," EPA 600/4-80-32, as amended and supplemented. This document may be obtained from the USEPA National Air and Radiation Environmental Laboratory, 540 S. Morris Ave., Montgomery, AL 36115-2601;

2. U.S. Department of Energy; "Environmental Measurements Laboratory -- Procedures Manual," HASL-300, 27th Ed., Vol. 1., as amended and supplemented. This document may be obtained from the US Department of Energy, Environmental Measurements Laboratory, 201 Varick St., 5th Floor, New York, NY 10014-4811; and/or

3. U.S. Environmental Protection Agency Eastern Environmental Radiation Facility; "Radiochemistry Procedures Manual," EPA 520/5-84-006, as amended and supplemented. This document may be obtained from the address in (c) 1 above.

(d) Any laboratory providing radiological analysis for soil shall be certified pursuant to N.J.A.C. 7:18 for radionuclide analysis in water and, in addition, shall have participated in and passed a soil intercomparison analysis administered by either the International Atomic Energy Agency or the U.S. Department of Energy's Environmental Measurements Laboratory within the year preceding the radiological analysis ***for the methods of interest***.

(e) Sampling and surveying for radioactive contamination shall be done in accordance with the protocol specified in that version of the Department of Environmental Protection's Field Sampling Procedure Manual's section on Radiological Assessment, incorporated herein by reference, in effect at the time of sampling and surveying which may be obtained by calling the Bureau of Environmental Radiation at (609) 984-5400 or from the Radiation Protection Program's web site at <http://www.state.nj.us/dep/rpp/index.htm>.

7:28-12.6 Remedial action selection

Remedial action selection for all sites contaminated with radioactive material shall be in accordance with N.J.A.C. 7:26E-5.

7:28-12.7 Remedial action requirements

The remedial action requirements for all sites contaminated with radioactive material shall be in accordance with N.J.A.C. 7:26E-6, with the exception of N.J.A.C. 7:26E-6.4, Post-remedial action requirements. Post-remedial sampling shall be conducted in accordance with the guidance provided in that version of the Department of Environmental Protection's Field Sampling Procedure Manual's section on Radiological Assessment, in effect at the time of the post-remedial sampling.

7:28-12.8 Radiation dose standards applicable to remediation of radioactive contamination of all real property

(a) Sites shall be remediated so that the incremental radiation dose to any person from any residual radioactive contamination at the site above that due to natural background radionuclide concentration, under either an unrestricted use remedial action, limited restricted use remedial action, or a restricted use remedial action, shall be as specified below:

1. For the sum of annual external gamma radiation dose (in effective dose equivalent) and intake dose (in committed effective dose equivalent)*, **including the groundwater pathway***: 15 millirem (0.15 milliSievert) total annual effective dose equivalent (15 mrem/yr TEDE).

2. For radon*-~~222~~*: three picocuries per liter (pCi/L) of radon gas (111 Bq/m³).

3. Radioactively contaminated ground water shall be remediated to comply with the New Jersey Groundwater Quality Standards rules, N.J.A.C. 7:9-6.

7:28-12.9 Minimum remediation standards for radionuclide contamination of soil

(a) For radioactive contamination in soils, the requirements of N.J.A.C. 7:28-12.8 shall be considered to be met for a specific radionuclide if:

1. Where only one radionuclide adds to the radioactive contamination of the site, the incremental concentration of the radionuclide above the natural background radionuclide concentration does not exceed the value in Table 1A, 1B (for unrestricted use), 2A, 2B (for limited restricted use), 3A, or 3B (for restricted use) below;

Table 1A Allowed Incremental ***Derived*** Concentration ***Guideline Level*** of Individual Radionuclides in Soils; Unrestricted Use Standards for Radioactive Contamination (pCi/g)⁽¹⁾

Radionuclide	Feet of Vertical Extent of Residual Radionuclides (VE)								
	VE1	VE2	VE3	VE4	VE5	VE6	VE7	VE8	VE9
U238 ⁽²⁾	*[59]* *54*	*[37]* *35*	*[27]* *26*	*[21]* *20*	17	*[15]* *14*	*[13]* *12*	11	10
U234 ⁽²⁾	*[63]* *62*	37	*[27]* *26*	21	17	14	12	11	10
Ra226 ⁽³⁾	3	*[3]* *2*	*[3]* *2*	*[3]* *2*	2	2	2	2	2
U235 ⁽²⁾	*[36]* *29*	*[25]* *22*	*[19]* *17*	*[15]* *14*	*[13]* *12*	*[11]* *10*	*[10]* *9*	8	*[8]* *7*
Ac227	3	2	2	2	2	2	2	2	2
Th232	*[3]* *2*	*[3]* *2*	2	2	2	2	*[2]* *1*	*[2]* *1*	*[2]* *1*

Table 1B Allowed Incremental ***Derived*** Concentration ***Guideline Level*** of Individual Radionuclides in Soils; Unrestricted Use Standards for Radioactive Contamination (Bq/g)⁽¹⁾

Radionuclide	Feet of Vertical Extent of Residual Radionuclides (VE)								
	VE1	VE2	VE3	VE4	VE5	VE6	VE7	VE8	VE9
U238 ⁽²⁾	*[2.19]]* *2.02*	*[1.36]]* *1.29*	*[0.99]]* *0.94*	*[0.77]]* *0.75*	*[0.64]]* *0.62*	*[0.54]]* *0.53*	*[0.47]]* *0.46*	0.41	*[0.37]]* *0.36*
U234 ⁽²⁾	*[2.32]]* *2.29*	*[1.38]]* *1.36*	*[0.99]]* *0.98*	*[0.77]]* *0.76*	*[0.63]]* *0.62*	0.53	0.46	0.41	0.36
Ra226 ⁽³⁾	*[0.13]]* *0.10*	*[0.11]]* *0.08*	*[0.11]]* *0.08*	*[0.10]]* *0.08*	*[0.09]]* *0.07*	*[0.09]]* *0.07*	*[0.08]]* *0.07*	*[0.08]]* *0.06*	*[0.08]]* *0.06*
U235 ⁽²⁾	*[1.35]]* *1.07*	*[0.92]]* *0.08*	*[0.70]]* *0.63*	*[0.55]]* *0.52*	*[0.48]]* *0.44*	*[0.41]]* *0.38*	*[0.36]]* *0.34*	*[0.29]]* *0.30*	*[0.29]]* *0.27*
Ac227	*[0.10]]* *0.09*	*[0.09]]* *0.08*	*[0.09]]* *0.08*	*[0.09]]* *0.08*	*[0.09]]* *0.08*	*[0.09]]* *0.08*	*[0.09]]* *0.08*	*[0.09]]* *0.07*	*[0.09]]* *0.07*
Th232	*[0.11]]* *0.08*	*[0.10]]* *0.07*	*[0.09]]* *0.07*	*[0.09]]* *0.06*	*[0.08]]* *0.06*	*[0.08]]* *0.06*	*[0.08]]* *0.06*	*[0.06]]* *0.05*	*[0.06]]* *0.05*

Table 2A Allowed Incremental ***Derived*** Concentration ***Guideline Level*** of Individual Radionuclides in Soils; Limited Restricted Use Standards for Radioactive Contamination (pCi/g)⁽¹⁾

Radionuclide	Feet of Vertical Extent of Residual Radionuclides (VE)								
	VE1	VE2	VE3	VE4	VE5	VE6	VE7	VE8	VE9
U238 ⁽²⁾	*[71]* *64*	*[44]* *41*	*[32]* *30*	*[25]* *24*	20	17	15	13	12
U234 ⁽²⁾	*[72]* *69*	*[43]* *42*	*[31]* *30*	24	*[20]* *19*	*[17]* *16*	14	13	11
Ra226 ⁽³⁾	*[7]* *5*	4	3	3	2	2	2	2	2
U235 ⁽²⁾	*[50]* *37*	*[33]* *27*	*[25]* *22*	*[20]* *18*	*[17]* *15*	*[14]* *13*	*[12]* *11*	*[11]* *10*	*[10]* *9*
Ac227	*[6]* *5*	*[6]* *5*	*[6]* *5*	*[6]* *5*	*[6]* *5*	*[6]* *5*	*[6]* *5*	*[6]* *4*	*[6]* *4*
Th232	*[6]* *3*	*[6]* *3*	*[6]* *3*	*[6]* *3*	*[6]* *3*	*[5]* *3*	*[5]* *3*	*[5]* *3*	*[5]* *3*

Table 2B Allowed Incremental ***Derived*** Concentration ***Guideline Level*** of Individual Radionuclides in Soils; Limited Restricted Use Standards for Radioactive Contamination (Bq/g)⁽¹⁾

Radionuclide	Feet of Vertical Extent of Residual Radionuclides (VE)								
	VE1	VE2	VE3	VE4	VE5	VE6	VE7	VE8	VE9
U238 ⁽²⁾	*[2.63]]* *2.37*	*[1.62]]* *1.52*	*[1.17]]* *1.12*	*[0.92]]* *0.88*	*[0.75]]* *0.73*	*[0.64]]* *0.62*	*[0.55]]* *0.54*	*[0.49]]* *0.48*	*[0.44]]* *0.43*
U234 ⁽²⁾	*[2.65]]* *2.56*	*[1.59]]* *1.56*	*[1.14]]* *1.12*	*[0.89]]* *0.88*	*[0.73]]* *0.72*	0.61	0.53	0.47	0.42
Ra226 ⁽³⁾	*[0.28]]* *0.19*	0.13	0.11	0.10	0.09	0.09	0.08	0.08	0.08
U235 ⁽²⁾	*[1.83]]* *1.38*	*[1.24]]* *1.01*	*[0.93]]* *0.80*	*[0.74]]* *0.65*	*[0.61]]* *0.55*	*[0.52]]* *0.48*	*[0.46]]* *0.42*	*[0.40]]* *0.38*	*[0.36]]* *0.34*
Ac227	*[0.22]]* *0.17*	*[0.22]]* *0.17*	*[0.22]]* *0.17*	*[0.22]]* *0.17*	*[0.22]]* *0.17*	*[0.22]]* *0.17*	*[0.21]]* *0.17*	*[0.21]]* *0.17*	*[0.21]]* *0.17*
Th232	*[0.24]]* *0.12*	*[0.24]]* *0.12*	*[0.23]]* *0.12*	*[0.22]]* *0.12*	*[0.21]]* *0.12*	*[0.20]]* *0.11*	*[0.19]]* *0.11*	*[0.17]]* *0.10*	*[0.17]]* *0.10*

Table 3A Allowed Incremental ***Derived*** Concentration ***Guideline Level*** of Individual Radionuclides in Soils; Restricted Use Standards for Radioactive Contamination⁽¹⁾ (pCi/g)

Feet of Uncontaminated Surface Soil (USS)		Feet of Vertical Extent of Residual Radionuclides (VE)								
		VE1	VE2	VE3	VE4	VE5	VE6	VE7	VE8	VE9
U238 ⁽²⁾	USS 1	*[84]* *82*	*[47]* *46*	*[33]* *32*	*[25]* *24*	*[21]* *20*	17	15	13	12
	USS 2	*[85]* *83*	*[47]* *46*	*[33]* *32*	25	*[21]* *20*	17	15	13	12
	USS 3	*[85]* *83*	*[47]* *46*	33	25	*[21]* *20*	17	15	13	12
	USS 4	*[85]* *83*	*[48]* *47*	33	25	*[21]* *20*	*[18]* *17*	15	13	12
	USS 5	*[86]* *85*	*[48]* *47*	33	*[26]* *25*	21	18	15	*[14]* *13*	12
U234 ⁽²⁾	USS 1	81	45	31	24	*[20]* *19*	*[17]* *16*	14	13	11
	USS 2	81	45	31	24	20	17	14	13	11
	USS 3	81	45	32	*[25]* *24*	20	17	*[15]* *14*	13	11
	USS 4	81	46	32	*[25]* *24*	20	17	15	13	11
	USS 5	83	46	32	25	20	17	15	13	12
Ra226 ⁽³⁾	USS 1	7	4	3	3	2	2	2	2	2
	USS 2	7	4	3	3	2	2	2	2	2
	USS 3	7	4	3	3	2	2	2	2	2
	USS 4	7	4	3	3	2	2	2	2	2
	USS 5	7	4	3	3	2	2	2	2	2
U235 ⁽²⁾	USS 1	*[67]* *62*	*[39]* *35*	*[27]* *25*	*[21]* *19*	*[17]* *16*	*[14]* *13*	*[12]* *11*	*[11]* *10*	*[10]* *9*
	USS 2	*[72]* *67*	*[40]* *37*	*[28]* *25*	*[21]* *20*	*[17]* *16*	*[14]* *13*	12	*[11]* *10*	*[10]* *9*
	USS 3	*[73]* *67*	*[40]* *37*	*[28]* *26*	*[21]* *20*	*[17]* *16*	14	*[13]* *12*	11	10
	USS 4	*[73]* *67*	*[40]* *37*	*[28]* *26*	*[21]* *20*	*[17]* *16*	*[15]* *14*	*[13]* *12*	11	10
	USS 5	*[73]* *68*	*[40]* *37*	*[28]* *26*	*[21]* *20*	*[18]* *17*	*[15]* *14*	*[13]* *13*	*[12]* *11*	10

Ac227	USS 1	*[20]* *17*	*[11]* *9*	*[8]* *6*	*[6]* *5*	*[6]* *5*	*[6]* *5*	*[6]* *5*	*[6]* *4*	*[6]* *4*
	USS 2	*[122]* *18*	*[12]* *10*	*[8]* *7*	*[8]* *7*	*[8]* *6*	*[7]* *5*	*[7]* *5*	*[7]* *5*	*[7]* *5*
	USS 3	*[22]* *18*	*[12]* *10*	*[12]* *10*	*[10]* *8*	*[8]* *6*	*[8]* *6*	*[8]* *6*	*[8]* *6*	*[8]* *6*
	USS 4	*[22]* *18*	*[18]* *15*	*[13]* *10*	*[10]* *8*	*[9]* *8*	*[9]* *8*	*[9]* *8*	*[9]* *8*	*[9]* *8*
	USS 5	*[32]* *26*	*[18]* *15*	*[13]* *10*	*[12]* *10*	*[12]* *10*	*[12]* *10*	*[12]* *10*	*[12]* *10*	*[12]* *10*
Th232	USS 1	*[21]* *15*	*[15]* *9*	*[11]* *7*	*[9]* *5*	*[7]* *4*	*[6]* *3*	*[5]* *3*	*[5]* *3*	*[5]* *3*
	USS 2	*[36]* *21*	*[18]* *10*	*[12]* *7*	*[9]* *5*	*[7]* *4*	*[6]* *3*	*[5]* *3*	*[5]* *3*	*[5]* *3*
	USS 3	*[36]* *21*	*[18]* *10*	*[12]* *7*	*[9]* *5*	*[7]* *4*	*[6]* *4*	*[6]* *4*	*[6]* *4*	*[6]* *4*
	USS 4	*[36]* *21*	*[18]* *10*	*[12]* *7*	*[9]* *5*	*[7]* *5*	*[7]* *5*	*[7]* *5*	*[7]* *5*	*[7]* *5*
	USS 5	*[36]* *21*	*[18]* *10*	*[12]* *7*	*[9]* *6*	*[9]* *6*	*[9]* *6*	*[9]* *6*	*[9]* *6*	*[9]* *6*

Table 3B Allowed Incremental ***Derived*** Concentration ***Guideline Level*** of Individual Radionuclides in Soils; Restrictd Use Standards for Radioactive Contamination⁽¹⁾ (Bq/g)

Feet of Uncontaminated Surface Soil (USS)		Feet of Vertical Extent of Residual Radionuclides (VE)								
		VE1	VE2	VE3	VE4	VE5	VE6	VE7	VE8	VE9
U238 ⁽²⁾	USS 1	*[3.11]* *3.03*	*[1.74]* *1.70*	*[1.21]* *1.18*	*[0.92]* *0.90*	*[0.76]* *0.74*	*[0.64]* *0.63*	*[0.55]* *0.54*	*[0.49]* *0.48*	*[0.44]* *0.43*
	USS 2	*[3.15]* *3.08*	*[1.75]* *1.71*	*[1.21]* *1.18*	*[0.94]* *0.92*	*[0.76]* *0.75*	[0.64]* *0.63*	*[0.56]* *0.55*	*[0.49]* *0.48*	*[0.44]* *0.43*
	USS 3	*[3.16]* *3.09*	*[1.75]* *1.71*	*[1.23]* *1.21*	*[0.94]* *0.92*	*[0.76]* *0.75*	*[0.64]* *0.63*	*[0.56]* *0.55*	0.49	0.44
	USS 4	*[3.16]* *3.09*	*[1.78]* *1.74*	*[1.23]* *1.21*	*[0.94]* *0.92*	*[0.77]* *0.75*	*[0.65]* *0.64*	0.56	*[0.50]* *0.49*	*[0.45]* *0.44*
	USS 5	*[3.20]* *3.14*	*[1.78]* *1.74*	*[1.23]* *1.21*	*[0.95]* *0.93*	*[0.78]* *0.77*	*[0.66]* *0.65*	*[0.57]* *0.56*	0.50	*[0.45]* *0.44*
U234 ⁽²⁾	USS 1	*[3.01]* *2.98*	*[1.67]* *1.66*	*[1.16]* *1.15*	*[0.89]* *0.88*	*[0.73]* *0.72*	0.61	0.53	0.47	0.42
	USS 2	*[3.01]* *2.98*	*[1.67]* *1.66*	*[1.16]* *1.15*	*[0.90]* *0.89*	0.73	*[0.62]* *0.61*	*[0.54]* *0.53*	0.47	0.42
	USS 3	*[3.01]* *2.98*	*[1.67]* *1.66*	*[1.18]* *1.17*	*[0.91]* *0.90*	*[0.74]* *0.73*	0.62	0.54	0.47	0.42
	USS 4	*[3.01]* *2.98*	*[1.71]* *1.70*	*[1.19]* *1.18*	*[0.91]* *0.90*	0.74	0.62	0.54	*[0.48]* *0.47*	*[0.43]* *0.42*
	USS 5	*[3.07]* *3.05*	*[1.71]* *1.70*	*[1.19]* *1.18*	*[0.92]* *0.91*	0.74	0.63	0.54	0.48	0.43
Ra226 ⁽³⁾	USS 1	0.28	0.13	0.11	0.10	0.09	0.09	0.08	0.08	0.08
	USS 2	0.28	0.13	0.11	0.10	0.09	0.09	0.08	0.08	0.08
	USS 3	0.28	0.13	0.11	0.10	0.09	0.09	0.08	0.08	0.08
	USS 4	0.28	0.13	0.11	0.10	0.09	0.09	0.08	0.08	0.08
	USS 5	0.28	0.13	0.11	0.10	0.09	0.09	0.08	0.08	0.08
U235 ⁽²⁾	USS 1	*[2.49]* *2.30*	*[1.43]* *1.30*	*[1.00]* *0.91*	*[0.77]* *0.70*	*[0.63]* *0.59*	*[0.53]* *0.49*	*[0.46]* *0.42*	*[0.40]* *0.38*	*[0.36]* *0.34*
	USS 2	*[2.68]* *2.47*	*[1.48]* *1.36*	*[1.03]* *0.94*	*[0.78]* *0.73*	*[0.63]* *0.59*	*[0.53]* *0.49*	*[0.46]* *0.43*	*[0.41]* *0.39*	*[0.37]* *0.35*

	USS 3	*[2.69]* *2.48*	*[1.48]* *1.36*	*[1.03]* *0.95*	*[0.78]* *0.73*	*[0.63]* *0.59*	*[0.53]* *0.50*	*[0.47]* *0.44*	*[0.42]* *0.40*	*[0.38]* *0.36*
	USS 4	*[2.69]* *2.49*	*[1.48]* *1.38*	*[1.03]* *0.95*	*[0.78]* *0.73*	*[0.64]* *0.60*	*[0.54]* *0.52*	*[0.48]* *0.45*	*[0.42]* *0.41*	*[0.38]* *0.37*
	USS 5	*[2.69]* *2.51*	*[1.48]* *1.38*	*[1.03]* *0.95*	*[0.79]* *0.74*	*[0.65]* *0.62*	*[0.56]* *0.53*	*[0.48]* *0.47*	*[0.43]* *0.42*	*[0.39]* *0.37*
	Ac227 USS 1	*[0.75]* *0.62*	*[0.43]* *0.34*	*[0.30]* *0.24*	*[0.23]* *0.18*	*[0.23]* *0.18*	*[0.23]* *0.18*	*[0.21]* *0.17*	*[0.21]* *0.17*	*[0.21]* *0.17*
	USS 2	*[0.80]* *0.66*	*[0.44]* *0.36*	*[0.30]* *0.24*	*[0.30]* *0.24*	*[0.29]* *0.23*	*[0.25]* *0.20*	*[0.24]* *0.19*	*[0.24]* *0.19*	*[0.24]* *0.19*
	USS 3	*[0.81]* *0.66*	*[0.44]* *0.36*	*[0.44]* *0.36*	*[0.36]* *0.29*	*[0.29]* *0.23*	*[0.29]* *0.23*	*[0.29]* *0.23*	*[0.29]* *0.23*	*[0.29]* *0.23*
	USS 4	*[0.81]* *0.66*	*[0.67]* *0.54*	*[0.47]* *0.37*	*[0.36]* *0.29*	*[0.35]* *0.28*	*[0.35]* *0.28*	*[0.35]* *0.28*	*[0.35]* *0.28*	*[0.35]* *0.28*
	USS 5	*[1.17]* *0.97*	*[0.67]* *0.54*	*[0.47]* *0.37*	*[0.45]* *0.36*	*[0.45]* *0.36*	*[0.45]* *0.36*	*[0.45]* *0.36*	*[0.45]* *0.36*	*[0.45]* *0.36*
	Th232 USS 1	*[0.81]* *0.56*	*[0.55]* *0.35*	*[0.42]* *0.25*	*[0.33]* *0.19*	*[0.26]* *0.15*	*[0.22]* *0.13*	*[0.19]* *0.11*	*[0.17]* *0.10*	*[0.17]* *0.10*
	USS 2	*[1.31]* *0.77*	*[0.66]* *0.39*	*[0.44]* *0.26*	*[0.33]* *0.19*	*[0.26]* *0.15*	*[0.22]* *0.13*	*[0.19]* *0.12*	*[0.19]* *0.12*	*[0.19]* *0.12*
	USS 3	*[1.31]* *0.77*	*[0.66]* *0.39*	*[0.44]* *0.26*	*[0.33]* *0.19*	*[0.26]* *0.15*	*[0.22]* *0.14*	*[0.22]* *0.14*	*[0.22]* *0.14*	*[0.22]* *0.14*
	USS 4	*[1.31]* *0.77*	*[0.66]* *0.39*	*[0.44]* *0.26*	*[0.33]* *0.19*	*[0.27]* *0.17*	*[0.27]* *0.17*	*[0.27]* *0.17*	*[0.27]* *0.17*	*[0.27]* *0.17*
	USS 5	*[1.31]* *0.77*	*[0.66]* *0.39*	*[0.44]* *0.26*	*[0.34]* *0.22*	*[0.34]* *0.22*	*[0.34]* *0.22*	*[0.34]* *0.22*	*[0.34]* *0.22*	*[0.34]* *0.22*

¹The allowed Incremental Concentrations are added to the natural background radionuclide concentration to obtain the absolute value of the allowed radionuclide concentration following site remediation.

²These allowable concentrations may however, further be limited by the chemical toxicity of uranium. Applicants should inquire with NJDEP's Site Remediation Program for the additional applicable chemical cleanup standards for uranium.

³When more than one nuclide is present, use the Radium-226 Table in Appendix A, incorporated herein by reference, for applying the sum of the fractions rule. Then use whatever number is more restrictive for radium-226*, **the value in Tables 1A through 3B or the value derived by using the sum of the fractions rule***.

2. Where more than one radionuclide contaminant is present at the site, their concentrations meet the sum of the fractions as described below:

$$\text{Sum of } \frac{CA_i}{C_i} \leq 1$$

where:

CA_i = the incremental concentration of radionuclide i at the site, and

C_i = the incremental allowed concentration of radionuclide i from Table 1A, 1B, 2A, 2B, 3A, or 3B above, if it were the only remaining radionuclide at the site; and

3. Natural background radionuclide concentration shall be established by the methods presented in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG-1575, EPA 402-R-97-018, and any subsequent revisions thereto*, **or as discussed in Chapter 12 of the Department's Field Sampling Procedures Manual***.

(b) As an alternate, the requirements of N.J.A.C. 7:28-12.8 shall be considered to be met for a specific radionuclide if:

1. Where only one radionuclide adds to the radioactive contamination of the site, the incremental concentration of the radionuclide above the natural background radionuclide concentration and the amount of uncontaminated surface soil meet the pre-mixing values in Table 4A, 4B (for unrestricted use), 5A, or 5B (for limited restricted use) below;

Table 4A Allowed Incremental ***Derived*** Concentration ***Guideline Level*** of Individual Radionuclides in Soils and Required Depth of USS; Pre-Mixing Values-Unrestricted Use (pCi/g)⁽¹⁾

Feet of Uncontaminated Surface Soil (USS)	Feet of Vertical Extent of Residual Radionuclides (VE)								
	VE1	VE2	VE3	VE4	VE5	VE6	VE7	VE8	VE9
U238 ⁽²⁾	USS 1	*[74]* *70*	*[40]* *39*	*[28]* *27*	21	17	*[15]* *14*	*[13]* *12*	11
	USS 2	*[77]* *76*	*[41]* *40*	*[28]* *21*	*[22]* *17*	*[18]* *14*	13	11	10
	USS 3	*[78]* *76*	*[42]* *41*	*[29]* *28*	22	*[18]* *17*	15	13	11

	USS 4	*[79]* *77*	42	*[29]* *28*	22	18	15	13	*[12]* *11*	10
	USS 5	*[79]* *78*	42	*[29]* *28*	22	18	15	13	12	10
U234 ⁽²⁾	USS 1	*[75]* *74*	40	27	21	17	14	12	11	10
	USS 2	*[75]* *74*	40	27	21	17	*[15]* *14*	13	11	10
	USS 3	*[75]* *74*	40	28	*[22]* *21*	17	15	13	11	10
	USS 4	76	42	28	22	18	15	13	11	10
	USS 5	78	42	28	22	18	15	13	11	10
Ra226 ⁽³⁾	USS 1	*[7]* *5**	*[4]* *3**	3	3	2	2	2	2	2
	USS 2	7	4	3	3	2	2	2	2	2
	USS 3	7	4	3	3	2	2	2	2	2
	USS 4	7	4	3	3	2	2	2	2	2
	USS 5	7	4	3	3	2	2	2	2	2
U235 ⁽²⁾	USS 1	*[55]* *43**	*[29]* * *26**	*[22]* *19**	*[17]* *15*	13	11	*[10]* *9*	8	*[8]* *7*
	USS 2	*[58]* * *51**	*[31]* * *29**	*[22]* *21*	*[17]* *15**	*[14]* *13*	11	*[10]* *9*	*[9]* *8*	8
	USS 3	*[62]* * *58**	*[34]* *31**	*[22]* *21*	*[17]* *16*	*[14]* *13*	11	10	9	8
	USS 4	*[67]* *62**	*[34]* *31**	*[22]* *21*	*[17]* *16*	13	*[12]* *11*	10	9	8
	USS 5	*[67]* *62**	*[34]* *32**	*[22]* *21*	*[17]* *16*	14	12	*[11]* *10*	9	*[8]* *8*
Ac227	USS 1	5* *3**	*[4]* *3**	3	*[3]* *2*	*[3]* *2*	*[3]* *2*	2	2	2
	USS 2	*[5]* *6**	*[5]* *4*	*[4]* *3*	*[4]* *3*	*[3]* *3*	3	3	3	3

	USS 3	*[9]* *8*	*[6]* *5*	*[5]* *4*	*[4]* *3*	4	*[4]* *3*	3*	3*	3*
	USS 4	*[12]* * *11*	*[7]* *6*	*[6]* *5*	*[5]* *4*	*[4]* *3*	*[4]* *3*	*[4]* *3*	*[4]* *3*	3*
	USS 5	*[14]* * *13*	*[9]* *8*	*[6]* *5*	5*	*[5]* *4*	4*	4*	*[4]* *3*	*[4]* *3*
	Th232 USS 1	*[7]* *4*	*[5]* *3*	*[4]* *2*	*[3]* *2*	*[3]* *2*	2	*[2]* *1*	*[2]* *1*	*[2]* *1*
	USS 2	*[11]* * *6*	*[7]* *4*	*[5]* *3*	3	*[3]* *2*	2	2	2	2
	USS 3	*[11]* * *8*	*[7]* *5*	*[5]* *4*	*[3]* *2*	*[3]* *2*	2	2	2	2
	USS 4	*[14]* *10*	*[7]* *6*	*[5]* *3*	*[3]* *2*	*[3]* *2*	*[3]* *2*	*[3]* *2*	*[3]* *2*	*[3]* *2*
	USS 5	*[15]* *11*	*[7]* *5*	*[5]* *3*	3	3	*[3]* *2*	*[3]* *2*	*[3]* *2*	*[3]* *2*

* Values were back-calculated to ensure 15 mrem/yr TEDE after mixing.

Table 4B Allowed Incremental ***Derived*** Concentration ***Guideline Level*** of Individual Radionuclides in Soils and Required Depth of USS; Pre-Mixing Values-Unrestricted Use (Bq/g)⁽¹⁾

Feet of Uncontaminated Surface Soil (USS)		Feet of Vertical Extent of Residual Radionuclides (VE)								
		VE1	VE2	VE3	VE4	VE5	VE6	VE7	VE8	VE9
U238 ⁽²⁾	USS 1	*[2.73]* *2.60*	*[1.49]* *1.46*	*[1.03]* *1.00*	*[0.79]* *0.77*	0.64	*[0.55]* *0.53*	*[0.47]* *0.46*	0.41	*[0.37]* *0.36*
	USS 2	*[2.86]* *2.80*	*[1.53]* *1.49*	*[1.05]* *1.03*	*[0.81]* *0.79*	*[0.65]* *0.64*	*[0.55]* *0.54*	*[0.47]* *0.46*	*[0.42]* *0.41*	*[0.38]* *0.37*
	USS 3	*[2.88]* *2.81*	*[1.55]* *1.51*	*[1.07]* *1.05*	*[0.81]* *0.80*	*[0.65]* *0.64*	*[0.55]* *0.54*	*[0.48]* *0.47*	0.42	*[0.38]* *0.37*
	USS 4	*[2.92]* *2.86*	*[1.57]* *1.54*	*[1.07]* *1.05*	*[0.81]* *0.80*	*[0.66]* *0.65*	*[0.56]* *0.55*	0.48	*[0.43]* *0.42*	0.38
	USS 5	*[2.93]* *2.88*	*[1.57]* *1.54*	*[1.07]* *1.05*	*[0.82]* *0.81*	*[0.67]* *0.66*	0.56	0.49	0.43	*[0.39]* *0.38*
U234 ⁽²⁾	USS 1	*[2.77]* *2.75*	*[1.48]* *1.46*	*[1.01]* *1.00*	*[0.77]* *0.76*	*[0.63]* *0.62*	0.53	0.46	0.41	0.36
	USS 2	*[2.77]* *2.75*	*[1.48]* *1.47*	*[1.02]* *1.01*	*[0.79]* *0.78*	0.64	*[0.54]* *0.53*	*[0.47]* *0.46*	0.41	0.37

	USS 3	*[2.78]* *2.75*	*[1.50]* *1.48*	1.04	0.80	0.64	0.54	0.47	0.41	0.37
	USS 4	*[2.82]* *2.80*	*[1.54]* *1.54*	1.05	0.80	0.65	0.55	0.47	*[0.42]* *0.41*	0.37
	USS 5	2.88	1.54	1.05	0.81	0.65	0.55	0.47	0.42	0.37
Ra226 ⁽³⁾	USS 1	*[0.28]* *0.18**	*[0.13]* *0.11**	0.11	0.10	0.09	*[0.09]* *0.08*	*[0.08]* *0.07*	*[0.08]* *0.06*	*[0.08]* *0.06*
	USS 2	0.28	0.13	0.11	0.10	0.09	*[0.09]* *0.08*	*[0.08]* *0.07*	*[0.08]* *0.07*	*[0.08]* *0.07*
	USS 3	0.28	0.13	0.11	0.10	0.09	0.09	0.08	0.08	0.08
	USS 4	0.28	0.13	0.11	0.10	0.09	0.09	0.08	0.08	0.08
	USS 5	0.28	0.13	0.11	0.10	0.09	0.09	0.08	0.08	0.08
U235 ⁽²⁾	USS 1	*[2.05]* *1.59**	*[1.07]* *0.96**	*[0.81]* *0.70**	*[0.62]* *0.57*	*[0.48]* *0.47*	*[0.42]* *0.39*	*[0.36]* *0.34*	*[0.29]* *0.30*	*[0.29]* *0.27*
	USS 2	*[2.15]* *1.89**	*[1.15]* *1.07**	*[0.81]* *0.78*	*[0.63]* *0.55**	*[0.51]* *0.47*	*[0.42]* *0.39*	*[0.36]* *0.34*	*[0.32]* *0.31*	*[0.29]* *0.28*
	USS 3	*[2.30]* *2.15**	*[1.26]* *1.15**	*[0.81]* *0.78*	*[0.63]* *0.59*	*[0.51]* *0.47*	*[0.42]* *0.40*	*[0.37]* *0.35*	*[0.33]* *0.32*	*[0.30]* *0.29*
	USS 4	*[2.49]* *2.30**	*[1.26]* *1.15**	*[0.81]* *0.79*	*[0.63]* *0.59*	0.48	*[0.43]* *0.41*	*[0.38]* *0.37*	*[0.34]* *0.33*	*[0.31]* *0.30*
	USS 5	*[2.49]* *2.30**	*[1.26]* *1.17*	*[0.81]* *0.79*	*[0.63]* *0.59*	*[0.52]* *0.50*	*[0.45]* *0.43*	*[0.40]* *0.38*	*[0.33]* *0.34*	*[0.30]* *0.31*
Ac227	USS 1	0.18*	*[0.15]* *0.10**	*[0.11]* *0.10*	*[0.09]* *0.08*	*[0.09]* *0.08*	*[0.09]* *0.08*	*[0.09]* *0.08*	*[0.09]* *0.07*	*[0.09]* *0.07*
	USS 2	*[0.18]* *0.21**	*[0.17]* *0.14*	*[0.13]* *0.11*	*[0.13]* *0.11*	0.11*	*[0.11]* *0.10*	*[0.11]* *0.09*	*[0.11]* *0.09*	*[0.11]* *0.09*
	USS 3	*[0.34]* *0.28*	*[0.21]* *0.18*	*[0.18]* *0.14**	*[0.15]* *0.11**	*[0.14]* *0.13*	0.13	*[0.11]* *0.09**	*[0.11]* *0.09**	*[0.11]* *0.09**
	USS 4	*[0.44]* *0.41**	*[0.26]* *0.22**	*[0.22]* *0.18**	*[0.17]* *0.14**	*[0.16]* *0.11**	*[0.16]* *0.11**	*[0.16]* *0.09**	*[0.16]* *0.09**	*[0.11]* *0.09**
	USS 5	*[0.52]* *0.48**	*[0.32]* *0.30**	*[0.22]* *0.18**	*[0.18]* *0.18**	*[0.18]* *0.14**	*[0.15]* *0.14**	*[0.15]* *0.14**	*[0.15]* *0.11**	*[0.15]* *0.11**
Th232	USS 1	*[0.27]* *0.15**	*[0.19]* *0.11**	*[0.15]* *0.09**	*[0.11]* *0.09*	*[0.11]* *0.07*	*[0.09]* *0.06*	*[0.08]* *0.06*	*[0.06]* *0.05*	*[0.06]* *0.05*
	USS 2	*[0.41]* *0.22**	*[0.27]* *0.15**	*[0.18]* *0.13*	*[0.11]* *0.10*	*[0.11]* *0.08*	*[0.09]* *0.07*	*[0.08]* *0.06*	*[0.08]* *0.06*	*[0.08]* *0.06*
	USS 3	*[0.41]* *0.30**	*[0.28]* *0.20*	*[0.18]* *0.14*	*[0.11]* *0.08**	*[0.11]* *0.08*	*[0.09]* *0.07*	*[0.09]* *0.07*	*[0.09]* *0.07*	*[0.09]* *0.07*
	USS 4	*[0.52]* *0.37**	*[0.28]* *0.21*	*[0.18]* *0.11**	*[0.11]* *0.08**	*[0.11]* *0.09*	*[0.11]* *0.09*	*[0.11]* *0.09*	*[0.11]* *0.09*	*[0.11]* *0.09*

	USS 5	*[0.52]* *0.42*	*[0.28]* *0.20**	*[0.18]* *0.11**	0.11	0.11	*[0.11]* *0.09**	*[0.11]* *0.09**	*[0.11]* *0.09**	*[0.11]* *0.09**
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* Values were back-calculated to ensure 15 mrem/yr TEDE after mixing.

Table 5A Allowed Incremental ***Derived*** Concentration ***Guideline Level*** of Individual Radionuclides in Soils and Required Depth of USS; Pre-Mixing Values-Limited Restricted Use (pCi/g)⁽¹⁾

Feet of Uncontaminated Surface Soil (USS)		Feet of Vertical Extent of Residual Radionuclides (VE)								
		VE1	VE2	VE3	VE4	VE5	VE6	VE7	VE8	VE9
U238 ⁽²⁾	USS 1	*[84]* *82*	*[47]* *45**	*[33]* *32*	*[25]* *24*	*[21]* *20*	17	15	13	12
	USS 2	*[85]* *83*	*[47]* *46*	*[33]* *32*	25	*[21]* *20*	17	15	13	12
	USS 3	*[85]* *83*	*[47]* *46*	33	25	*[21]* *20*	17	15	13	12
	USS 4	*[85]* *83*	*[48]* *47*	33	25	*[21]* *20*	*[18]* *17*	15	13	12
	USS 5	*[86]* *85*	*[48]* *47*	33	*[26]* *25*	21	18	15	*[14]* *13*	12
U234 ⁽²⁾	USS 1	81	45	31	24	*[20]* *19*	*[17]* *16*	14	13	11
	USS 2	81	45	31	24	20	17	14	13	11
	USS 3	81	45	32	*[25]* *24*	20	17	*[15]* *14*	13	11
	USS 4	81	46	32	*[25]* *24*	20	17	15	13	11
	USS 5	83	46	32	25	20	17	15	13	*[12]* *11**
Ra226 ⁽³⁾	USS 1	7	4	3	3	2	2	2	2	2
	USS 2	7	4	3	3	2	2	2	2	2
	USS 3	7	4	3	3	2	2	2	2	2
	USS 4	7	4	3	3	2	2	2	2	2
	USS 5	7	4	3	3	2	2	2	2	2

U235 ⁽²⁾	USS 1	*[67]* *62*	*[38]* *32*	*[27]* *24*	*[21]* *19*	*[17]* *16*	*[14]* *13*	*[12]* *11*	*[11]* *10*	*[10]* *9*
	USS 2	*[72]* *67*	*[40]* *37*	*[28]* *25*	*[21]* *20*	*[17]* *16*	*[14]* *13*	12	*[11]* *10*	*[10]* *9*
	USS 3	*[73]* *67*	*[40]* *37*	*[28]* *26*	*[21]* *20*	*[17]* *16*	14	*[13]* *12*	11	10
	USS 4	*[73]* *67*	*[40]* *37*	*[28]* *26*	*[21]* *20*	*[17]* *16*	*[15]* *14*	*[13]* *12*	11	10
	USS 5	*[73]* *68*	*[40]* *37*	*[28]* *26*	*[21]* *20*	*[18]* *17*	*[15]* *14*	13	*[12]* *11*	10
Ac227	USS 1	*[12]* *9*	*[9]* *7*	*[8]* *6*	*[6]* *5*	*[6]* *5*	*[6]* *5*	*[6]* *5*	*[6]* *4*	*[6]* *4*
	USS 2	*[18]* *14*	*[12]* *10*	*[8]* *7*	*[8]* *7*	*[8]* *6*	*[7]* *5*	*[7]* *5*	*[7]* *5*	*[7]* *5*
	USS 3	*[22]* *18*	*[12]* *10*	*[12]* *10*	*[10]* *8*	*[8]* *6*	*[8]* *6*	*[8]* *6*	*[8]* *6*	*[8]* *6*
	USS 4	*[22]* *18*	*[18]* *15*	*[13]* *10*	*[10]* *8*	*[9]* *8*	*[9]* *7*	*[9]* *7*	*[9]* *7*	*[9]* *7*
	USS 5	*[32]* *26*	*[18]* *15*	*[13]* *10*	*[12]* *10*	*[12]* *9*	*[11]* *8*	*[10]* *8*	*[10]* *7*	*[9]* *7*
Th232	USS 1	*[15]* *7*	*[11]* *5*	*[10]* *5*	*[9]* *4*	*[7]* *4*	*[6]* *3*	*[5]* *3*	*[5]* *3*	*[5]* *3*
	USS 2	*[22]* *10*	*[15]* *7*	*[12]* *6*	*[9]* *5*	*[7]* *4*	*[6]* *3*	*[5]* *3*	*[5]* *3*	*[5]* *3*
	USS 3	*[30]* *14*	*[18]* *8*	*[12]* *7*	*[9]* *5*	*[7]* *4*	*[6]* *4*	*[6]* *4*	*[6]* *4*	*[6]* *4*
	USS 4	*[36]* *17*	*[18]* *10*	*[12]* *7*	*[9]* *5*	*[7]* *5*	*[7]* *5*	*[7]* *5*	*[7]* *5*	*[7]* *5*
	USS 5	*[36]* *20*	*[18]* *10*	*[12]* *7*	*[9]* *6*	*[9]* *6*	*[9]* *6*	*[9]* *6*	*[9]* *5*	*[9]* *5*

* Values were back-calculated to ensure 15 mrem/yr TEDE after mixing.

Table 5B Allowed Incremental ***Derived***Concentration ***Guideline Level***of Individual Radionuclides in Soils and Required Depth of USS; Pre-Mixing Values-Limited Restrictd Use⁽¹⁾ (Bq/g)

Feet of Uncontaminated Surface Soil (USS)		Feet of Vertical Extent of Residual Radionuclides (VE)								
		VE1	VE2	VE3	VE4	VE5	VE6	VE7	VE8	VE9
U238 ⁽²⁾	USS 1	*[3.11]* *3.03*	*[1.74]* *1.67**	*[1.21]* *1.18*	*[0.92]* *0.90*	*[0.76]* *0.74*	*[0.64]* *0.63*	*[0.55]* *0.54*	*[0.49]* *0.48	*[0.44]* *0.43*
	USS 2	*[3.15]* *3.08*	*[1.75]* *1.71*	*[1.21]* *1.18*	*[0.94]* *0.92*	*[0.76]* *0.75*	*[0.64]* *0.63*	*[0.56]* *0.55*	*[0.49]* *0.48	*[0.44]* *0.43*
	USS 3	*[3.16]* *3.09*	*[1.75]* *1.71*	*[1.23]* *1.21*	*[0.94]* *0.92*	*[0.76]* *0.75*	*[0.64]* *0.63*	*[0.56]* *0.55*	0.49	0.44
	USS 4	*[3.16]* *3.09*	*[1.78]* *1.74*	*[1.23]* *1.21*	*[0.94]* *0.92*	*[0.77]* *0.75*	*[0.65]* *0.64*	0.56	*[0.50]* *0.49	*[0.45]* *0.44*
	USS 5	*[3.20]* *3.14*	*[1.78]* *1.74*	*[1.23]* *1.21*	*[0.95]* *0.93*	*[0.78]* *0.77*	*[0.66]* *0.65*	*[0.57]* *0.56*	0.50	*[0.45]* *0.44*
U234 ⁽²⁾	USS 1	*[3.01]* *2.98*	*[1.67]* *1.66*	*[1.16]* *1.15*	*[0.89]* *0.88*	*[0.73]* *0.72*	0.61	0.53	0.47	0.42
	USS 2	*[3.01]* *2.98*	*[1.67]* *1.66*	*[1.16]* *1.15*	*[0.90]* *0.89*	0.73	*[0.62]* *0.61*	*[0.54]* *0.53*	0.47	0.42
	USS 3	*[3.01]* *2.98*	*[1.67]* *1.66*	*[1.18]* *1.17*	*[0.91]* *0.90*	*[0.74]* *0.73*	0.62	0.54	0.47	0.42
	USS 4	*[3.01]* *2.98*	*[1.71]* *1.70*	*[1.19]* *1.18*	*[0.91]* *0.90*	0.74	0.62	0.54	*[0.48]* *0.47	*[0.43]* *0.42*
	USS 5	*[3.07]* *3.05*	*[1.71]* *1.70*	*[1.19]* *1.18*	*[0.92]* *0.91*	0.74	0.63	0.54	0.48	0.43
Ra226 ⁽³⁾	USS 1	0.28	0.13	0.11	0.10	0.09	0.09	0.08	0.08	0.08
	USS 2	0.28	0.13	0.11	0.10	0.09	0.09	0.08	0.08	0.08
	USS 3	0.28	0.13	0.11	0.10	0.09	0.09	0.08	0.08	0.08
	USS 4	0.28	0.13	0.11	0.10	0.09	0.09	0.08	0.08	0.08
	USS 5	0.28	0.13	0.11	0.10	0.09	0.09	0.08	0.08	0.08
U235 ⁽²⁾	USS 1	*[2.49]* *2.30*	*[1.41]* *1.18**	*[1.00]* *0.89**	*[0.77]* *0.70*	*[0.63]* *0.59*	*[0.53]* *0.49*	*[0.46]* *0.42*	*[0.40]* *0.38*	*[0.36]* *0.34*
	USS 2	*[2.68]* *2.47*	*[1.48]* *1.36*	*[1.03]* *0.94*	*[0.78]* *0.73*	*[0.63]* *0.59*	*[0.53]* *0.49*	*[0.46]* *0.43*	*[0.41]* *0.39*	*[0.37]* *0.35*
	USS 3	*[2.69]* *2.48*	*[1.48]* *1.36*	*[1.03]* *0.95*	*[0.78]* *0.73*	*[0.63]* *0.59*	*[0.53]* *0.50*	*[0.47]* *0.44*	*[0.42]* *0.40*	*[0.38]* *0.36*

Ac227	USS 4	*[2.69]* *2.49*	*[1.48]* *1.38*	*[1.03]* *0.95*	*[0.78]* *0.73*	*[0.64]* *0.60*	*[0.54]* *0.52*	*[0.48]* *0.45*	*[0.42]* *0.41*	*[0.38]* *0.37*
	USS 5	*[2.69]* *2.51*	*[1.48]* *1.38*	*[1.03]* *0.95*	*[0.79]* *0.74*	*[0.65]* *0.62*	*[0.56]* *0.53*	*[0.48]* *0.47*	*[0.43]* *0.42*	*[0.39]* *0.37**
	USS 1	*[0.44]* *0.33*	*[0.33]* *0.26**	*[0.30]* *0.24*	*[0.23]* *0.18*	*[0.23]* *0.18*	*[0.23]* *0.18*	*[0.21]* *0.17*	*[0.21]* *0.17*	*[0.21]* *0.17*
	USS 2	*[0.67]* *0.52**	*[0.44]* *0.36*	*[0.30]* *0.24*	*[0.30]* *0.24*	*[0.29]* *0.23*	*[0.25]* *0.20*	*[0.24]* *0.19*	*[0.24]* *0.19*	*[0.24]* *0.19*
	USS 3	*[0.81]* *0.66*	*[0.44]* *0.36*	*[0.44]* *0.36*	*[0.36]* *0.29*	*[0.29]* *0.23*	*[0.29]* *0.23*	*[0.29]* *0.23*	*[0.29]* *0.23*	*[0.29]* *0.23*
Th232	USS 4	*[0.81]* *0.66*	*[0.67]* *0.54*	*[0.47]* *0.37*	*[0.36]* *0.29*	*[0.35]* *0.28*	*[0.35]* *0.26**	*[0.35]* *0.26**	*[0.35]* *0.26**	*[0.35]* *0.26**
	USS 5	*[1.17]* *0.97*	*[0.67]* *0.54*	*[0.47]* *0.37*	*[0.45]* *0.36*	*[0.45]* *0.33**	*[0.41]* *0.28**	*[0.37]* *0.28**	*[0.37]* *0.26**	*[0.33]* *0.26**
	USS 1	*[0.55]* *0.26**	*[0.41]* *0.18**	*[0.37]* *0.18**	*[0.33]* *0.15**	*[0.26]* *0.15*	*[0.22]* *0.13*	*[0.19]* *0.11*	*[0.17]* *0.10*	*[0.17]* *0.10*
	USS 2	*[0.81]* *0.37**	*[0.55]* *0.26**	*[0.44]* *0.22**	*[0.33]* *0.19*	*[0.26]* *0.15*	*[0.22]* *0.13*	*[0.19]* *0.12*	*[0.19]* *0.12*	*[0.19]* *0.12*
	USS 3	*[1.11]* *0.52**	*[0.66]* *0.30**	*[0.44]* *0.26*	*[0.33]* *0.19*	*[0.26]* *0.15*	*[0.22]* *0.14*	*[0.22]* *0.14*	*[0.22]* *0.14*	*[0.22]* *0.14*
	USS 4	*[1.31]* *0.63**	*[0.66]* *0.39*	*[0.44]* *0.26*	*[0.33]* *0.19*	*[0.27]* *0.17*	*[0.27]* *0.17*	*[0.27]* *0.17*	*[0.27]* *0.17*	*[0.27]* *0.17*
	USS 5	*[1.31]* *0.74**	*[0.66]* *0.39*	*[0.44]* *0.26*	*[0.34]* *0.22*	*[0.34]* *0.22*	*[0.34]* *0.22*	*[0.34]* *0.22*	*[0.34]* *0.17**	*[0.34]* *0.17**

* Values were back-calculated to ensure 15 mrem/yr TEDE after mixing.

- (1) The allowed Incremental Concentrations are added to the natural background radionuclide concentration to obtain the absolute value of the allowed radionuclide concentration before mixing.
- (2) These allowable concentrations may however, further be limited by the chemical toxicity of uranium. Applicants should inquire with NJDEP's Site Remediation Program for the additional applicable chemical cleanup standards for uranium.
- (3) When more than one nuclide is present, use the Radium-226 Table in Appendix B, incorporated herein by reference, for applying the sum of the fractions rule. Then use whatever number is more restrictive for radium-226*, **the value in Tables 4A through 5B or the value derived using the sum of the fractions rule***.

*Values were back-calculated to ensure 15 mrem/yr TEDE after mixing.

2. After it is established that the concentrations in Table 4A, 4B, 5A, or 5B above are met, the layer of residual radionuclides shall be mixed thoroughly with the layer of uncontaminated surface soil to achieve a uniform concentration*, **as outlined in Chapter 12 of the Department's Field Sampling Procedures Manual***, throughout the soil column;

3. Where more than one radionuclide contaminant is present at the site, their concentrations

meet the sum of the fractions as described below:

$$\text{Sum of } \frac{CA_i}{C_i} \leq 1$$

where:

CA_i = the incremental concentration of radionuclide i at the site, and

C_i = the incremental allowed concentration of radionuclide i from Table 4A, 4B, 5A, or 5B above, if it were the only remaining radionuclide at the site; and

4. The requirement in (a) 3 above shall be met.

7:28-12.10 Petition for alternative remediation standards for radioactive contamination

(a) In lieu of using the minimum remediation standards for radioactive contamination of soil found at N.J.A.C. 7:28-12.9, a person may petition the Department for an alternative soil standard for radioactive contamination. Such an alternate soil cleanup standard:

1. Shall not result in incremental doses, for sum of annual external radiation dose and intake dose, exceeding 15 mrem/yr (0.15 mSv/yr) total effective dose equivalent;
2. Shall not result in incremental concentrations exceeding three pCi/L (111 Bq/m³) of radon in indoor air in the lowest level of the building; and
2. Shall not result in radionuclide in groundwater levels exceeding those in the New Jersey Groundwater Quality Standards in N.J.A.C. 7:9-6.

(b) The Department shall not consider a petition for an alternative soil standard for radionuclides that is supported by increasing, in any manner, the allowed incremental background dose value of 15 mrem/yr (0.15 mSv/yr) or the allowed incremental radon in air concentration of three pCi/L (111 Bq/m³), or varying the parameters listed in Tables 6 or 7 below.

Table 6

Parameter	Unrestricted	Limited or Restricted
Indoor onsite breathing rate (m ³ /hr)	0.63	*[1.20]** 1.4*
Outdoor onsite breathing rate (m ³ /hr)	1.40	*[1.20]** 1.4*
Soil ingestion rate (g/yr)	70	12.5
Homegrown crop ingestion rate (g/yr)	*[14,235]** 17,136*	0
Drinking water consumption rate (L/yr)	700	700
Shielding factor through basement or slab	0.20	0.20

Shielding factor through walls	0.80	0.80
Shielding factor outside	1.00	1.00
[fraction of time spent indoors on site]	*[70%]*	*[18%]*
[fraction of time spent outdoors on site]	*[5%]*	*[5%]*

Table 7
Soil to Vegetation Transfer Factors

Element	pCi/g plant (wet) to pCi/g soil (dry)
Th	1E-3
Ra	4E-2
Pb	1E-2
Po	1E-3
U	2.5E-3
Ac	2.5E-3
Pa	1E-2
Bi	1E-1

(c) The Department shall consider petitions only in cases where site-specific or waste specific factors, and/or site design features are used in performing the dose assessment, which are different than those used by the Department in establishing the soil concentrations in N.J.A.C. 7:28-12.9. Factors which the Department shall consider in a petition for an alternate soil standard include, but are not limited to:

1. The chemical or physical state of the radioactive material;
3. Site-specific soil characteristics, depth to groundwater and other geological and hydrogeological characteristics which may substantially change the potential dose from radionuclides, as compared to the values listed in Tables 8 and 9 below.
- 4.

Table 8
Generic Site Input Parameters for Groundwater Pathway Analysis

Dimensions of contaminated zone, LxW (m)	100x100
Percolation rate (vertical Darcy velocity, m/yr)	0.5
Volumetric water content in contaminated zone (m ³ /m ³)	0.35
Volumetric water content in unsaturated zone (m ³ /m ³)	0.2
Bulk density of contaminated zone (g/m ³)	1.6
Bulk density of saturated zone (g/m ³)	1.6
Unsaturated zone thickness(distance from bottom of source to aquifer, m)	0.5
Porosity of aquifer	0.45
Longitudinal dispersivity in aquifer (m)	9
Transverse dispersivity in aquifer (m)	4
Pore velocity in aquifer (m/yr)	4
Well screen thickness (mixing depth, m)	10

Table 9
Sorption Coefficients used for Groundwater Pathway Analysis

Isotopes	Kd (mg/L)
uranium	35
thorium	3,200
radium	500
lead	270
proactinium	550
actinium	450

3. Use of caps, covers, sealants, geotextile membranes, limits on the vertical extent of radioactive contamination remaining on site and/or other engineering or institutional controls that reduce potential exposures to radioactive materials; and

4. Changes in indoor and outdoor occupancy times, which are justified by land uses other than residential or commercial.

(d) A petition for an alternate soil standard shall include an analysis demonstrating how and why the difference in factors such as those in Tables *[6 through]* ***8 and* 9** above ***and/or indoor and outdoor occupancy times*** will result in substantially different soil standards than those in N.J.A.C. 7:28-12.9.

(e) Regardless of the factors used by the petitioner, the Department shall not approve alternative standard petitions that include institutional and engineering controls where failure of those controls, not including the failure of a radon remediation system, would result in more than

100 mrem (one mSv) total annual effective dose equivalent.

(f) In the event the Department determines that sufficient evidence exists to support consideration of an alternative soil standard, the petitioner shall submit a written analysis which demonstrates compliance with the dose limits in N.J.A.C. 7:28-12.9 including:

1. The remedial action informational requirements of N.J.A.C. 7:26E-6; and
2. A dose assessment analysis, including:
 - i An estimate of the radiation doses received by a post-remediation on-site resident for an unrestricted use remedial action, or by a resident or an employee (of a proposed commercial use facility) for a limited restricted use remedial action;
 - ii A presentation of all equations or other mathematical techniques used, either directly or embodied in a computer model, to predict the movement of radionuclides and/or their resulting radiation dose;
 - iii Groundwater radionuclide concentration calculations which shall be extended for a period of 1,000 years;
 - iv A presentation of all numerical input parameters to equations or computer models, the range of values for those parameters, including reference sources, the value selected for use and the basis for that selection;
 - v A presentation of other relevant factors and assumptions used in the analyses, such as site-specific geology, land use, etc.;
 - vi An analysis of which input parameters, when varied, would most significantly affect radiation dose results, commonly referred to as a sensitivity analysis; and
 - vii An analysis of both continued use of existing structures and future use scenarios. Future use scenarios shall include, if applicable, the construction of buildings for either unrestricted use remedial actions or limited restricted use remedial actions, including excavations for basements and/or footings.

(g) Engineering controls or institutional controls may be incorporated as part of a petition for an alternative remediation standard provided that these controls will be durable and implemented for an appropriate period of time to achieve their intended purpose.

(h) Computer models acceptable to the Department may be used by the petitioner for an alternative soil standard to confirm that the requirements of N.J.A.C. 7:28-12.9 have been and will continue to be met.

7:28-12.11 Requirements pertaining to engineering or institutional controls

(a) All remediation proposals shall designate the intended use(s) of the property. Such intended use(s) shall be restricted as necessary to prevent future exposure, and shall otherwise be consistent with current and projected State and local zoning designations or land uses. For sites not remediated to the unrestricted use standards in N.J.A.C. 7:28-12.9, the Department shall define the nature and duration of all appropriate engineering or institutional controls necessary to meet the standards in N.J.A.C. 7:28-12.9 or 12.10(a), based upon the particular conditions of the

site.

(b) In order for any remediation under this subchapter requiring engineering controls or institutional controls to meet the standards in N.J.A.C. 7:28-12.9 or 12.10(a), the person responsible for conducting the remediation shall, in addition to meeting the provisions of N.J.S.A. 58:10B-13:

1. Implement all necessary actions, as determined by the Department, to assure that such engineering or institutional controls are being implemented and maintained for an appropriate period of time; and

2. Provide for the costs of implementing and maintaining the requisite active engineered or institutional controls for an appropriate period of time.

7:28-12.12 Requirements pertaining to a change in land use

(a) Any subsequent proposed use of a property that is different from the intended use (other than unrestricted use remedial actions) described in the original remediation proposal shall require a prior review and prior approval by the Department. To initiate this review, 90 calendar days prior to a proposed change in land use, the person proposing such use shall prepare and submit to the Department, at the Bureau of Environmental Radiation, PO Box 415, Trenton, NJ 08625-0415, and to each affected municipality, a brief written description of the new proposed use as compared to the intended use upon which the original remediation was based including all planned soil excavations, and any additional remedial actions to be implemented.

(b) If the Department determines that the proposed new use may cause the dose limitations of N.J.A.C. 7:28-12.8 to be exceeded, the person requesting the use change shall be required to prepare and submit to the Department's Bureau of Environmental Radiation, PO Box 415, Trenton, NJ 08625-0415, a dose assessment analysis, containing the information required under N.J.A.C. 7:28-12.10(f)2, (g), and (h), to ascertain whether the dose limitation requirements of N.J.A.C. 7:28-12.8 will be met for the proposed new use.

(c) In preparing the dose assessment analysis, the person may incorporate into the new use plan new remedial measures such as different radionuclide in soil concentrations, or radioactive contamination vertical extents, and/or new engineering or institutional controls, provided that for engineering or institutional controls, the person responsible for conducting the remediation provides for the cost of implementing and maintaining them as specified in N.J.A.C. 7:28-12.11(c)3.

7:28-12.13 Requirements pertaining to the final status survey

The final status survey is performed to demonstrate that a site meets the remediation standards. It shall be done in accordance with that version of the Department of Environmental Protection's Field Sampling Procedures Manual's section on Radiological Assessment, which is incorporated herein by reference, in effect at the time of the survey which may be obtained by calling the Bureau of Environmental Radiation at (609) 984-5400 or from the Radiation Protection Program's web site at <http://www.state.nj.us/dep/rpp/index.htm>. ***Chapter 12 of the Department's Field Sampling Procedures Manual follows the methodology provided in MARSSIM with some modifications.***

Appendix A

Allowed Incremental* **Derived*** Concentration ***Guideline Levels*** (pCi/g) for the Gamma and Intake Pathways ⁽¹⁾

Nuclide	Feet of Vertical Extent of Residual Radionuclide (VE)								
	VE1	VE2	VE3	VE4	VE5	VE6	VE7	VE8	VE9
Ra226 Unrestricted Use Standards	3	*[3]* *2*	*[3]* *2*	*[3]* *2*	2	2	2	2	2
Ra226 Limited Restricted Use Standards	*[10]* *5*	*[10]* *5*	*[10]* *5*	*[9]* *5*	*[9]* *5*	*[8]* *5*	*[8]* *5*	*[7]* *4*	*[7]* *4*

Allowed Incremental ***Derived*** Concentration ***Guideline Levels*** (pCi/g) for the Gamma and Intake Pathways ⁽¹⁾

Feet of Uncontaminated Surface Soil (USS)		Feet of Vertical Extent of Residual Radionuclide (VE)								
		VE1	VE2	VE3	VE4	VE5	VE6	VE7	VE8	VE9
Ra226* Restricted Use Standards	USS 0	10	10	10	9	9	8	8	7	7]*
	USS 1	*[30]* *22*	*[23]* *15*	*[18]* *10*	*[13]* *8*	*[11]* *6*	*[9]* *5*	*[8]* *5*	*[7]* *4*	*[7]* *4*
	USS 2	*[44]* *28*	*[25]* *15*	*[18]* *10*	*[13]* *8*	*[11]* *6*	*[9]* *5*	*[8]* *5*	*[8]* *5*	*[8]* *5*
	USS 3	*[44]* *28*	*[25]* *15*	*[18]* *10*	*[13]* *8*	*[11]* *6*	*[9]* *6*	*[9]* *6*	*[9]* *6*	*[9]* *6*
	USS 4	*[44]* *28*	*[25]* *15*	*[18]* *10*	*[13]* *8*	*[11]* *7*	*[11]* *7*	*[11]* *7*	*[11]* *7*	*[11]* *7*
	USS 5	*[44]* *28*	*[25]* *15*	*[18]* *10*	*[13]* *9*	*[13]* *9*	*[13]* *9*	*[13]* *9*	*[13]* *9*	*[13]* *9*

Appendix A

Allowed Incremental ***Derived*** Concentration ***Guideline Levels*** (Bq/g) for the Gamma and

Intake Pathways ⁽¹⁾

Nuclide	Feet of Vertical Extent of Residual Radionuclide (VE)								
	VE1	VE2	VE3	VE4	VE5	VE6	VE7	VE8	VE9
Ra226 Unrestricted Use Standards	0.13	*[0.11]* *0.09*	*[0.11]* *0.09*	*[0.10]* *0.09*	*[0.10]* *0.09*	0.09	0.09	0.08	0.08
Ra226 Limited Restricted Use Standards	*[0.38]* *0.18*	*[0.38]* *0.18*	*[0.37]* *0.18*	*[0.35]* *0.18*	*[0.33]* *0.18*	*[0.31]* *0.18*	*[0.29]* *0.18*	*[0.26]* *0.15*	*[0.26]* *0.15*

Allowed Incremental ***Derived*** Concentration ***Guideline Level*** (Bq/g) for the Gamma and Intake Pathways ⁽¹⁾

Feet of Uncontaminated Surface Soil (USS)		Feet of Vertical Extent of Residual Radionuclide (VE)								
		VE1	VE2	VE3	VE4	VE5	VE6	VE7	VE8	VE9
Ra226* Restricted Use Standards	USS 0	0.38	0.38	0.37	0.35	0.33	0.31	0.29	0.26	0.26]*
	USS 1	*[1.11]* *0.81*	*[0.84]* *0.55*	*[0.65]* *0.37*	*[0.50]* *0.30*	*[0.40]* *0.22*	*[0.34]* *0.18*	*[0.29]* *0.18*	*[0.26]* *0.15*	*[0.26]* *0.15*
	USS 2	*[1.64]* *1.04*	*[0.93]* *0.56*	*[0.65]* *0.37*	*[0.50]* *0.30*	*[0.40]* *0.22*	*[0.34]* *0.18*	*[0.29]* *0.18*	*[0.29]* *0.18*	*[0.29]* *0.18*
	USS 3	*[1.64]* *1.04*	*[0.93]* *0.56*	*[0.65]* *0.37*	*[0.50]* *0.30*	*[0.40]* *0.22*	*[0.34]* *0.22*	*[0.34]* *0.22*	*[0.34]* *0.22*	*[0.34]* *0.22*
	USS 4	*[1.64]* *1.04*	*[0.93]* *0.56*	*[0.65]* *0.37*	*[0.50]* *0.30*	*[0.40]* *0.26*	*[0.40]* *0.26*	*[0.40]* *0.26*	*[0.40]* *0.26*	*[0.40]* *0.26*
	USS 5	*[1.64]* *1.04*	*[0.93]* *0.56*	*[0.65]* *0.37*	*[0.50]* *0.33*	*[0.50]* *0.33*	*[0.50]* *0.33*	*[0.50]* *0.33*	*[0.50]* *0.33*	*[0.49]* *0.33*

⁽¹⁾ These Ra226 concentration numbers may be used only when more than one radionuclide is present for the sum of the fractions rule at N.J.A.C. 7:28-12.9(b).

Appendix B

Allowed Incremental ***Derived*** Concentration ***Guideline Levels*** (pCi/g) for the Gamma and Intake Pathways⁽¹⁾

Feet of Uncontaminated Surface Soil (USS)		Feet of Vertical Extent of Residual Radionuclide (VE)								
		VE1	VE2	VE3	VE4	VE5	VE6	VE7	VE8	VE9
Ra226*[Unrestricted Use Pre-mixing Values	USS 0	3	3	3	3	2	2	2	2	2]*
	USS 1	*[8]* *5**	*[5]* *3**	*[4]* *3*	*[4]* *3*	3	3	2	2	2
	USS 2	*[12]* *7**	*[7]* *4**	*[5]* *4**	*[4]* *3**	3	3	2	2	2
	USS 3	*[15]* *7*	*[8]* *5**	*[6]* *4**	4	3	3	3	3	3
	USS 4	*[15]* *11*	*[8]* *7**	*[6]* *5**	4	3	3	3	3	3
	USS 5	*[15]* *13**	8	6	4	4	4	4	4	4
Ra226*[Limited Restricted Use Pre-mixing Values	USS 0	10	10	10	9	9	8	8	7	7]*
	USS 1	*[23]* *11**	*[17]* *8**	*[15]* *7**	*[13]* *7**	*[11]* *6**	*[9]* *6**	*[8]* *5**	*[7]* *5**	*[7]* *5**
	USS 2	*[34]* *16**	*[23]* *11**	*[17]* *9**	*[13]* *8**	*[11]* *7**	*[9]* *6**	*[8]* *6**	*[8]* *5**	*[8]* *5**
	USS 3	*[44]* *21**	*[25]* *13**	*[18]* *10**	*[13]* *9**	*[11]* *7**	*[9]* *6**	*[9]* *6**	*[9]* *6**	*[9]* *6**
	USS 4	*[44]* *26**	*[25]* *16**	*[18]* *12**	*[13]* *9**	*[11]* *8**	*[11]* *7**	*[11]* *7**	*[11]* *6**	*[11]* *6**
	USS 5	*[44]* *31**	*[25]* *18**	*[18]* *11**	*[13]* *10**	*[13]* *9**	*[13]* *8**	*[13]* *7**	*[13]* *7**	*[13]* *7**

* Back-calculated to ensure 15 mrem/yr TEDE after mixing

Allowed Incremental ***Derived*** Concentration ***Guideline Levels*** (Bq/g) for the Gamma and Intake Pathways⁽¹⁾

Feet of Uncontaminated Surface Soil (USS)		Feet of Vertical Extent of Residual Radionuclide (VE)								
		VE1	VE2	VE3	VE4	VE5	VE6	VE7	VE8	VE9
Unrestricted Use Pre-mixing Values	Ra226*[USS 0	0.13	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08]*
	USS 1	*[0.28]* * 0.18 **	*[0.19]* * 0.12 **	*[0.15]* * 0.12 **	*[0.13]* * 0.12 **	0.12	0.10	0.09	0.08	0.08
	USS 2	*[0.47]* * 0.25 **	*[0.28]* * 0.15 **	*[0.21]* * 0.15 **	*[0.16]* * 0.15 **	*[0.13]* * 0.12 **	0.11	0.09	0.09	0.09
	USS 3	*[0.57]* * 0.25 **	*[0.32]* * 0.18 **	*[0.22]* * 0.17 **	0.17	0.14	0.11	0.11	0.11	0.11
	USS 4	*[0.59]* * 0.40 **	*[0.32]* * 0.25 **	*[0.22]* * 0.18 **	0.17	0.13	0.13	0.13	0.13	0.13
	USS 5	*[0.59]* * 0.48 **	0.32	0.22	0.16	0.16	0.16	0.16	0.16	0.16
Limited Restricted Use Pre-mixing Values	Ra226*[USS 0	0.38	0.38	0.37	0.35	0.33	0.31	0.29	0.26	0.26]*
	USS 1	*[0.85]* * 0.40 **	*[0.63]* * 0.30 **	*[0.56]* * 0.26 **	*[0.50]* * 0.26 **	*[0.40]* * 0.22 **	*[0.34]* * 0.22 **	*[0.29]* * 0.18 **	*[0.26]* * 0.18 **	*[0.26]* * 0.18 **
	USS 2	*[1.26]* * 0.59 **	*[0.85]* * 0.40 **	*[0.63]* * 0.33 **	*[0.50]* * 0.30 **	*[0.40]* * 0.26 **	*[0.34]* * 0.22 **	*[0.29]* * 0.22 **	*[0.29]* * 0.18 **	*[0.29]* * 0.18 **
	USS 3	*[1.64]* * 0.77 **	*[0.93]* * 0.48 **	*[0.65]* * 0.37 **	*[0.50]* * 0.33 **	*[0.40]* * 0.26 **	*[0.34]* * 0.22 **	*[0.34]* * 0.22 **	*[0.34]* * 0.22 **	*[0.34]* * 0.22 **
	USS 4	*[1.64]* * 0.96 **	*[0.93]* * 0.59 **	*[0.65]* * 0.44 **	*[0.50]* * 0.33 **	*[0.40]* * 0.30 **	*[0.40]* * 0.26 **	*[0.40]* * 0.26 **	*[0.40]* * 0.22 **	*[0.40]* * 0.22 **
	USS 5	*[1.64]* * 1.15 **	*[0.93]* * 0.67 **	*[0.65]* * 0.41 **	*[0.50]* * 0.37 **	*[0.50]* * 0.33 **	*[0.50]* * 0.30 **	*[0.50]* * 0.26 **	*[0.50]* * 0.26 **	*[0.49]* * 0.26 **

* Back-calculated to ensure 15 mrem/yr TEDE after mixing

⁽¹⁾ These Ra226 concentration numbers may be used only when more than one radionuclide is present for the sum of the fractions rule at N.J.A.C. 7:28-12.9(b).